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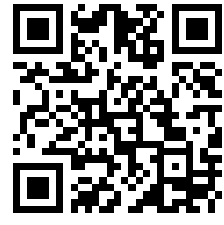

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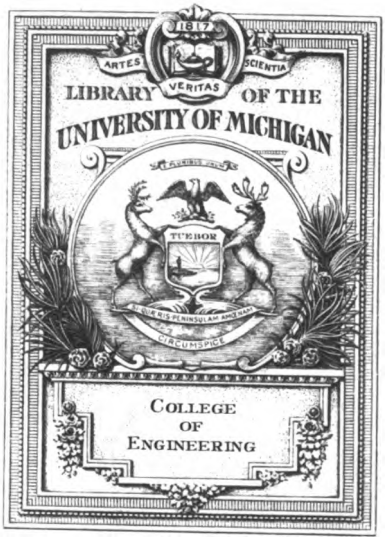

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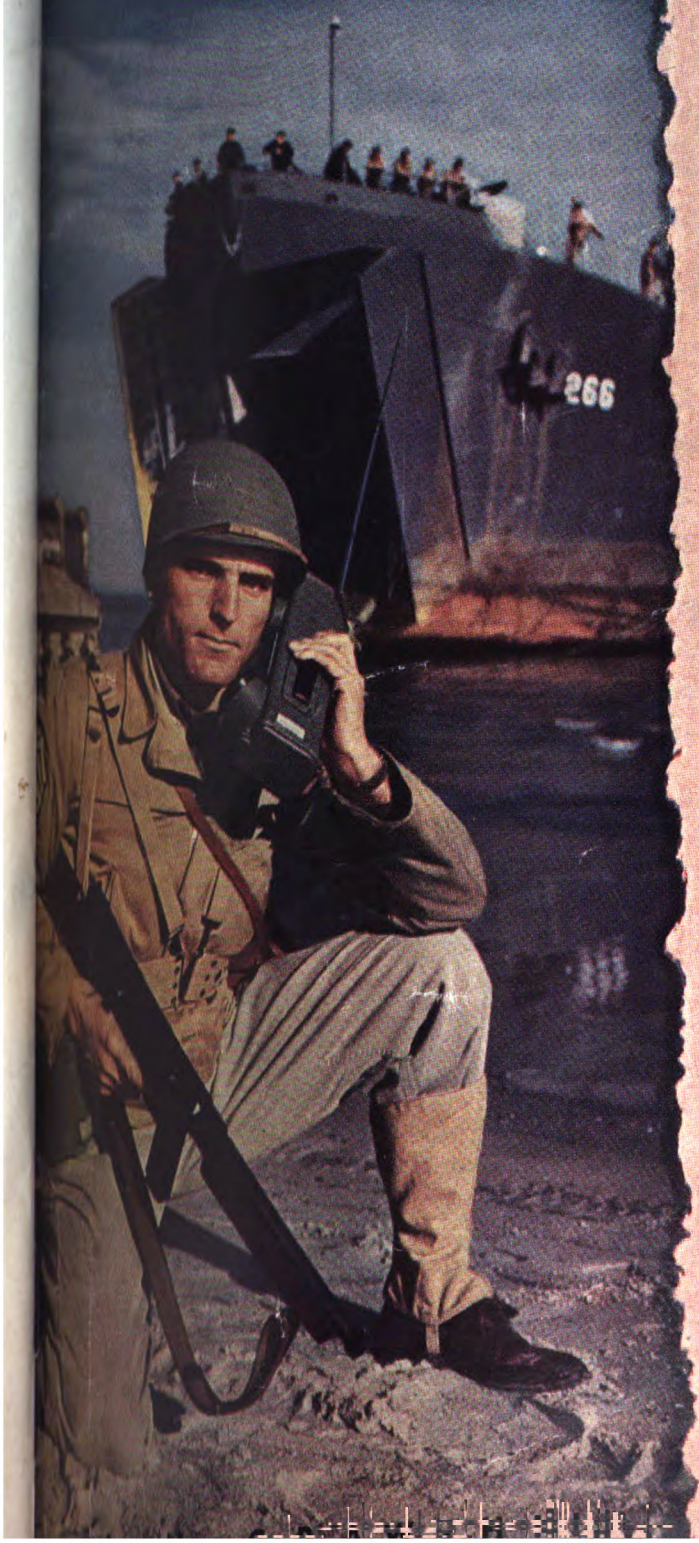

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Your sons, husbands and brothers who are standing today upon the battlefronts are fighting for more than victory in war. They are fighting for a new world of freedom and peace.

We, upon whom has been placed the responsibility of leading the American forces, appeal to you with all possible earnestness to invest in War Bonds to the fullest extent of your capacity.

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Douglas MacArthur
E. J. King
Dwight D. Eisenhower
C. W. Nimitz
H. H. Arnold

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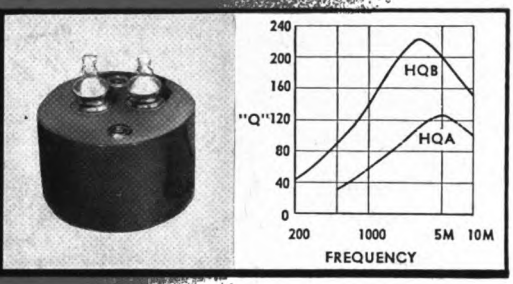
FOR INDUCTORS



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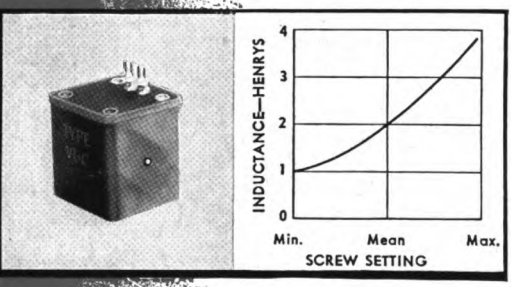
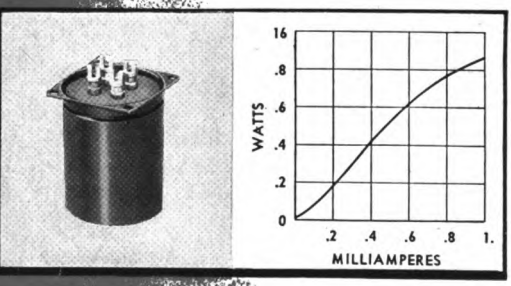
This series of toroid wound high stability inductors are available from 5 Mhy. to 2 Hys. Voltage stability is excellent, hum pickup is very low. Temperature effects are negligible. HQA units 1-13/16" in diameter by 1-3/16" high.



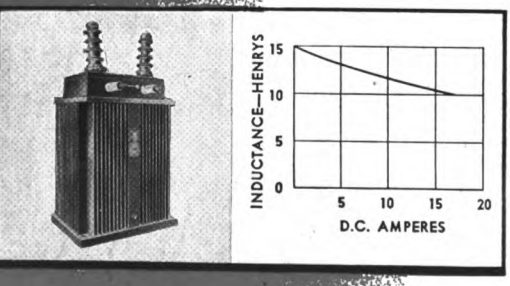
TYPE VI-C VARIABLE INDUCTORS

These inductors are available in optimum values from 10 Mhy. to 10 Hys. They are tunable over a wide range by inserting an Allen Head wrench in the adjusting screw. Units measure 1¼" x 1-7/16" x 1-7/16".



SENSITIVE SATURABLE INDUCTORS

UTC Saturable Inductors cover a wide range of application for magnetic amplification and control. These units are supplied to specific requirements. The curve shown illustrates a high sensitive type, showing DC saturation vs. AC watts into load.



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UTC supplies power supply components for every type of application, ranging from a one-third ounce reactor, which measures ⅝" x 7/16" x ¾", to the 10,000 pound, broadcast station, plate supply reactor, illustrated.

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JULY • 1945

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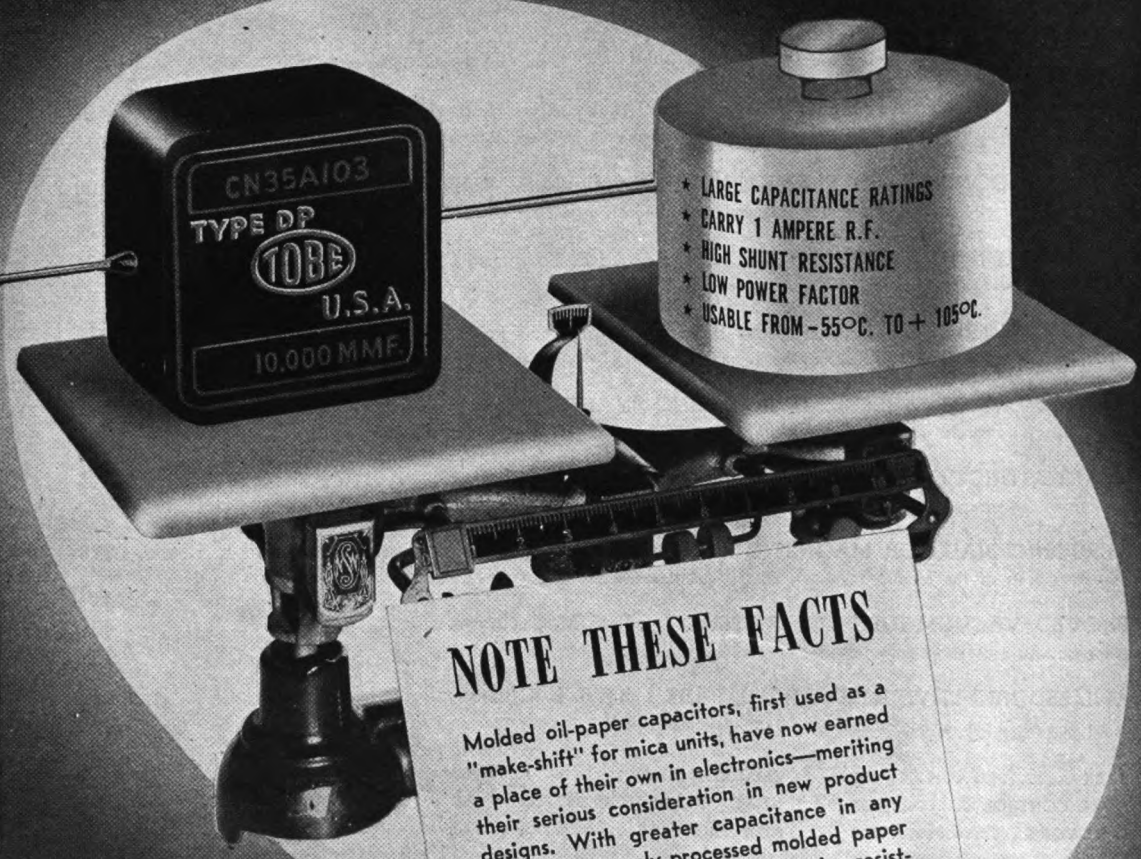

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CROSS TALK

▶**FM's FUTURE . . .** FCC's decision to postpone final allocation of f-m channels until fall, as reported elsewhere in this issue, has a background of controversy which deserves most careful analysis. The debate started, last year, as a technical argument concerning v-h-f propagation, a field where differences of opinion are the rule—not the exception. Since the economic aspects of fm were involved, the argument quickly broadened to include questions of public and private investment. The economic arguments were two: (1) any change in the f-m band would make obsolete equipment in public hands and (2) any change would depreciate, if not wholly wipe out, the broadcasters' investment in existing f-m stations.

First, the public investment: if a set owner wishes to retain his pre-war f-m set to receive fm on any new band, he has to install a simple converter. Moreover, such a converter is required, *in any event,* to cover extension of the existing f-m band to provide more channels for a nationwide, competitive system. The necessity for such extension has never been in question at any stage of the discussion.

Second, the broadcasters' investment; at the beginning of the controversy, the broadcaster may well have believed that by insisting on retention of the present band he could preserve his investment intact. But here, again, technical judgment has indicated otherwise. It is now agreed, by all parties to the argument, that high-power f-m broadcasting stations should move above 50 Mc to avoid F_2-layer interference. Since all present allocations are below 50 Mc, this means that all high-power statoins (50-kw and 10-kw power) must move in any event. These stations represent a very large part of the broadcasters' present investment.

In short, as far as investment is concerned, public or private, additional costs must be borne to allow fm to expand.

The remaining items of controversy are technical: what is the effect of frequency, over the range from 44 to 108 Mc, on (1) the extent of the several forms of interference and (2) the coverage afforded? Here, also, there is much more general agreement than appeared earlier in the year. As noted, there is agreement that F_2 reflections may give trouble, during the sunspot maximum, at the lower frequencies, between high power stations. The argument turns on a matter of degree: where in the region between 44 and 108 Mc will the interference cease to be troublesome? Major Armstrong believes that the trouble will be negligible above 60 Mc. He favors the lowest of the three FCC alternative bands, 50-68 Mc, with the high power stations in the upper 10 Mc of that range. E-layer reflections are now discounted as being of negligible importance compared to the F_2 reflections and those from the troposphere. As for tropospheric effects, experience has indicated that they become more serious as the frequency increases. Further study this summer will establish the facts.

The matter of coverage seems to favor the lower frequencies, but not unalterably so. High transmitting power is harder to get at 108 Mc than at 44, but our guess is that, with tubes shortly to become available, 50 kw can be obtained anywhere in this band. The question of field strength washes out. The volts-per-meter are higher as the frequency goes up but the length of the antenna decreases in proportion, so the developed voltage at the receiver terminals remains fixed for a given transmitter power, so long as free-space propagation is considered.

The effect of the earth's surface on propagation is, of course, pronounced. Further measurements are needed to establish the extent of absorption effects, but the diffraction effects are fairly evident. Shadows are sharper, and the diminution of signal strength beyond the horizon more rapid, as the frequency is increased. These matters can be proved in the coming months.

On the F_2-layer question, unfortunately, no proof can be forthcoming until the next sunspot maximum. In the meantime we must guess, by extrapolation from previous experience, what the effects will be. Of course the extrapolation procedure must be scrutinized with the greatest care, without professional bias or personal rancor, if we are to make a sound estimate.

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Final FCC 25-30,000 Mc Allocations

ON MAY 17 the Federal Communications Commission announced final frequency allocations for that portion of the radio spectrum lying between 25 and 30,000 Mc. (*Proposed allocations for the range between 10 and 25,000 kc were released May 21 and appear in the* NEWS OF THE INDUSTRY *department of this issue of* ELECTRONICS.) In the final allocations the frequencies between 44 and 108 Mc were left unassigned pending the outcome of measurements and tests of f-m transmission.

FM Held Up

The unassigned space between 44 and 108 Mc will ultimately provide a total of 36 Mc for television, 18 for fm, 4 for amateurs, 4 for non-government fixed and mobile services, and 2 for facsimile. The precise allocation within this region remains undecided but the Commission indicates three possible alternatives which turn upon the exact location of fm. The three alternatives would place that service between 50 and 68 Mc, between 68 and 86 Mc, or between 84 and 102 Mc.

A joint committee composed of Commission and industry engineers will conduct tests during the summer, when sporadic-E tranmissions are expected to be at their maximum, to determine which of the three alternatives is most desirable.

The 25 to 30,000-Mc allocations will be ordered into effect service by service, with the Commission taking into account such factors as the availability of manpower and materials and the preparation of rules and standards. It is pointed out that all non-government services above 450 Mc are to be established on an experimental basis pending adequate showing as to need and technical requirements. It is also pointed out that allocations are subject to change if this becomes necessary in order to conform to the provisions of international agreements such as those which may be made at the forthcoming Inter-American Conference in Rio de Janeiro.

Allocations vs. Proposals

Study of the final allocations disclosed three principle changes from the Commission's proposal of last January:

The band in the 27-Mc region, available for scientific, industrial and medical devices including diathermy machines, was enlarged from the 30-kc channel width originally proposed to 270 kc.

Television has been assigned a thirteenth channel between 174 and 180 Mc. In the original proposal this channel had been assigned to air navigation aids.

In the original proposal 6 Mc was left unassigned, for ultimate use by television, fm, facsimile or the safety services, upon a showing of need. In the final allocations this 6 Mc is definitely assigned. Initially, 2 Mc will be available for facsimile exclusively, contiguous to the 18-Mc wide f-m assignment, wherever f-m is placed. Manufacturers of f-m receivers are urged to include the 2 Mc in the tuning range, since ultimately facsimile service may be shifted above 400 Mc and the 2 Mc would in this case be assigned to f-m. (As in the original proposal, facsimile may also be transmitted by f-m stations when they are not rendering aural service.) The remaining originally unassigned 4 Mc is made available to the safety services.—W. MACD.

THREE ALTERNATIVE ALLOCATION PROPOSALS FOR 44-108 MC

Freq. in Mc	United States Allocation	Proposed International Allocation
44-48	Amateur	Amateur
48-50	Facsimile	Broadcasting
50-54	EDUCATIONAL F-M BROADCASTING	Broadcasting
54-68	COMMERCIAL F-M BROADCASTING	Broadcasting
68-74	Television	Broadcasting fixed and mobile
74-78	Non-gov. fixed and mobile (2) (3)	Fixed and mobile except aero. (2) (3)
78-84	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
84-90	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
90-96	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
96-102	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
102-108	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
44-50	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
50-56	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
56-60	Amateur	Amateur
60-66	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
66-68	Facsimile	Broadcasting
68-72	EDUCATIONAL F-M BROADCASTING	Broadcasting
72-86	COMMERCIAL F-M BROADCASTING (2)	Broadcasting (2)
86-92	Television	Broadcasting fixed and mobile
92-98	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
98-104	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
104-108	Non-gov. fixed and mobile (3)	Fixed and mobile except aero. (3)
44-50	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
50-54	Amateur	Amateur
54-60	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
60-66	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
66-72	Television fixed and mobile (1)	Broadcasting fixed and mobile (1)
72-78	Television fixed and mobile (1) (2)	Broadcasting fixed and mobile (1) (2)
78-84	Television broadcasting	Broadcasting fixed and mobile
84-88	EDUCATIONAL F-M BROADCASTING	Broadcasting
88-102	COMMERCIAL F-M BROADCASTING	Broadcasting
102-104	Facsimile	Broadcasting
104-108	Non-gov. fixed and mobile (3)	Fixed and mobile except aero. (3)

NOTES

(1) Provision may be made for the operation of non-governmental fixed and mobile services (such as police control and relay circuits, point-to-point marine control circuits, forestry fixed circuits, rural telephone, broadcast studio-to-transmitter links, railroad terminal and yard operations) upon proper showing of need, and that such channels may be shared on a mutually non-interfering basis.

(2) Aeronautical markers to remain on 75 Mc with adequate guard bands as long as required or until moved to another suitable frequency.

(3) On the basis of an average channel width of 50 kc in this 4-Mc wide band there will be 36 channels for police, 12 channels for fire, 10 channels for special emergency including highway maintenance (provisional), 8 channels for forestry and conservation, 6 channels for urban transit, forestry and conservation, 6 channels for power, petroleum and other industries requiring similar radio service, and 2 channels for provisional and experimental.

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Assignments subject to change only in the event that subsequent international agreements require it. Region between 44 and 108 Mc left unassigned so that performance of fm at three different frequencies within this range may be further studied. Allocations above 450 Mc are considered experimental

Freq. in Mc	United States Allocation	Proposed International Allocation
25.015-27.185	Gov. and non-gov. fixed and mobile (*) (1)	Fixed and mobile except aero. and maritime (*)
27.185-27.455	Scientific, industrial and medical (**)	Scientific, industrial and medical (**)
27.455-28	Gov. and non-gov. fixed and mobile (*) (1)	Fixed and mobile, except maritime (*)
28-29.700	Amateur	Amateur
29.700-30	Gov. and non-gov. fixed and mobile (*) (1)	Fixed and mobile except maritime (*)
30-30.5	Government (2)	Fixed and mobile except aero. (2)
30.5-32	Non-gov. fixed and mobile (2) (3)	Fixed and mobile except aero. (2) (3)
32-33	Government (2)	Fixed and mobile except aero. (2)
33-34	Non-gov. fixed and mobile (2) (3)	Fixed and mobile except aero. (2) (3)
34-35	Government (2)	Fixed and mobile except aero. (2)
35-36	Non-gov. fixed and mobile (2) (3)	Fixed and mobile except aero. (2)
36-37	Government (2)	Fixed and mobile except aero. (2)
37-38	Non-gov. fixed and mobile (2) (3)	Fixed and mobile except aero. (2) (3)
38-39	Government (2)	Fixed and mobile except aero. (2)
39-40	Non-gov. fixed and mobile (2) (3)	Fixed and mobile except aero. (2) (3)
40-40.96	Government (2)	Fixed and mobile except aero. (2)
40.96-41	Scientific, industrial and medical	Scientific, industrial and medical
41-42	Government (2)	Fixed and mobile except aero. (2)
42-44	Non-gov. fixed and mobile (2) (4)	Fixed and mobile except aero. (2) (4)

SEE THREE ALTERNATIVE ALLOCATION PROPOSALS FOR FREQUENCIES BETWEEN 44 MC AND 108 MC

108-112	Government	Air navigation localizers
112-118	Government	Air navigation ranges
118-122	Airport control	Aero. mobile airport control
122-132	Aero mobile primarily non-gov.	Aero. mobile
132-144	Government	Fixed and aero. mobile
144-148	Amateur	Amateur
148-152	Government	Fixed and aero. mobile
152-162	Non-gov. fixed and mobile (5)	Fixed and mobile except aero. (5)
162-174	Government	Fixed and mobile
174-180	Television and government	Broadcasting fixed and mobile
180-186	Television and government	Broadcasting fixed and mobile
186-192	Television fixed and mobile (6)	Broadcasting fixed and mobile (6)
192-198	Television fixed and mobile (6)	Broadcasting fixed and mobile (6)
198-204	Television fixed and mobile (6)	Broadcasting fixed and mobile (6)
204-210	Television fixed and mobile (6)	Broadcasting fixed and mobile (6)
210-216	Television fixed and mobile (6)	Broadcasting fixed and mobile (6)
216-220	Government	Fixed and mobile
220-225	Amateur	Amateur
225-328.6	Military, and civil aviation channels	Fixed and mobile
328.6-335.4	Glide path air navigation aids	Glide path air navigation aids
335.4-400	Military, and civil aviation channels	Fixed and mobile
400-420	Government, including radiosonde	Fixed and mobile, including radiosonde
420-450	Amateur and air navigation (7)	Air navigation and amateur (7)
450-460	Non-gov. fixed and mobile (8)	Air navigation (8)
460-470	Citizen's radio	Fixed and mobile
470-480	Facsimile broadcasting	Broadcasting
480-920	Television	Broadcasting
920-940	Experimental broadcast services	Broadcasting
940-960	Fixed and experimental broadcasting (9)	Fixed and broadcasting (9)
960-1145	Navigation aids	Navigation aids
1145-1245	Amateur	Amateur
1245-1325	Television relay	Fixed and mobile except aero.
1325-1375	Non-gov. fixed and mobile including aero.	Fixed and mobile
1375-1600	Government	Fixed and mobile
1600-1700	Air navigation aids	Air navigation aids
1700-1750	Meteorological	Meteorological
1750-2100	Non-gov. fixed and mobile	Fixed and mobile except aero.
2100-2300	Government	Fixed and mobile
2300-2450	Amateur	Amateur
2450-2700	Non-gov. fixed and mobile	Fixed and mobile except aero.
2700-2900	Meteorological and air navigation aids	Meteorological and air navigation aids
2900-3700	Navigation aids	Navigation aids
3700-3900	Air navigation aids	Air navigation aids
3900-4400	Non-gov. fixed and mobile	Fixed and mobile except aero.
4400-5000	Government	Fixed and mobile
5000-5250	Instrument landing air navigation aids	Instrument landing air navigation aids
5250-5650	Amateur	Amateur
5650-7050	Non-gov. fixed and mobile	Fixed and mobile except aero.
7050-8500	Government	Fixed and mobile
8500-10000	Government	Special navigation aids
10000-10500	Amateur	Amateur
10500-13000	Non-gov. fixed and mobile	Fixed and mobile except aero.
13000-16000	Government	Fixed and mobile
16000-18000	Non-gov. fixed and mobile	Fixed and mobile except aero.
18000-21000	Government	Fixed and mobile
21000-22000	Amateur	Amateur
22000-26000	Government	Fixed and mobile
26000-30000	Non-gov. fixed and mobile	Fixed and mobile except aero.
30000-Up	Experimental	Experimental

NOTES

(*) Power to be limited internationally to 500 watts peak.

(**) All equipment to be adjusted and maintained as closely as possible to 27.320 Mc.

(1) On the basis of an average channel width of 25 kc in the band between 25 and 28 Mc there will be 24 relay broadcast and geophysical channels, 12 channels for power, petroleum and other industries requiring similar radio service, 10 provisional and experimental channels, 7 aeronautical channels primarily for flight tests and flying schools, and 6 relay press and motion picture channels.

(2) No change proposed in existing services between 30 and 44 Mc outside the continental United States.

(3) On the basis of an initial channel width of 40 kc in the band between 30 and 40 Mc there will be 36 police channels, 29 channels for forestry and conservation (6 of them shared with maritime mobile and another 6 shared with urban transit), 20 channels for general highway mobile (for all types of service such as marine, land vehicles, aircraft, etc.; pending final determination of the best method of operation these channels will be assigned on an experimental basis, with 12 channels assigned to development on a common carrier basis, 4 going to trucks and 4 going to buses, except in those cases where it is shown that a different distribution is more desirable), 15 channels for fire, 11 for government use, 7 for power, petroleum and other industries requiring similar radio service, 6 for special emergency, 5 for maritime mobile and geophysical, 5 for urban transit, provisional and experimental, 2 for provisional and experimental, and 2 for provisional and experimental with antenna input limited to 5 watts peak.

(4) On the basis of an average channel width initially of 40 kc in the band between 42 and 44 Mc there will be 24 police channels, 20 general highway mobile channels (subject to the same division as general highway mobile service in note 3), 5 maritime mobile and geophysical channels, and 1 provisional and experimental channel.

(5) On the basis of an average channel width of 60 kc in the band between 152 and 162 Mc there will be 60 channels for railroads, 36 channels for police, 24 channels for urban mobile (subject to the same division as general highway mobile service in notes 3 and 4) and for rural subscriber and short-distance toll telephone, 12 for fire, 12 for relay broadcast, 8 for maritime mobile, 6 for power, petroleum and other industries requiring similar radio service, 4 for relay press, forestry, conservation and geophysical, and 4 for provisional and experimental. Services now operating between 156 and 162 Mc may continue temporarily on a non-interfering basis.

(6) Provision may be made for the operation of non-governmental fixed and mobile services (such as police control and relay circuits, point-to-point, marine control circuits, forestry fixed circuits, rural telephone, broadcast studio-to-transmitter links, railroad terminal and yard operations) upon proper showing of need, and that such channels may be shared on a mutually non-interfering basis.

(7) To be used temporarily for special air navigation aids. Band to be exclusively amateur when no longer required for such aids, with amateur peak power meanwhile being limited to 50 watts.

(8) To be temporarily used for special air navigation aids and reserved for non-government services when no longer required for such aids.

(9) May be used by low-power fixed point-to-point stations for such services as studio-transmitter links, control circuits, and police fixed facsimile circuits.

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Broadcast Band

Use of boosters to fill in dead spots or extend coverage when a directional antenna system is not feasible. The unattended booster transmitter may be fed by r-f line as with WWDC or by space radiation as with WINX, using standard telephone lines for remote control

By
ROSS H. BEVILLE
Chief Engineer
Station WWDC, Washington, D. C.

MUCH interest has been exhibited recently by broadcast engineers in a system of r-f signal reinforcement usually known as an r-f booster or a synchronous amplifier. Since late 1940 when the system was first used in connection with a standard broadcast station, it has proved both practical and of considerable benefit in the improvement of coverage in dead-spot areas and in aiding to override interference from other stations operating on the same or adjacent frequencies.

Uses for Boosters

The use of a booster system is desirable for local-channel stations that are limited by FCC regulations to 250 watts or less and are not allowed to use a directional antenna system, and for other stations even with directional antennas, to cover adequately an urban area having high noise level or absorption; WSAI is an example. A low-power station with several stragegically located boosters can provide coverage comparable to that of a much higher-power station; such a system was planned for Worcester, Mass. but was shelved due to wartime restrictions.

Three booster systems are now in operation, two being in Washington, D. C. (WWDC and WINX) and one in Cincinnati (WSAI). A construction permit has been authorized for a fourth system, now under construction at Ft. Benning, Ga., that will be operated as a satellite of WRBL in Columbus.

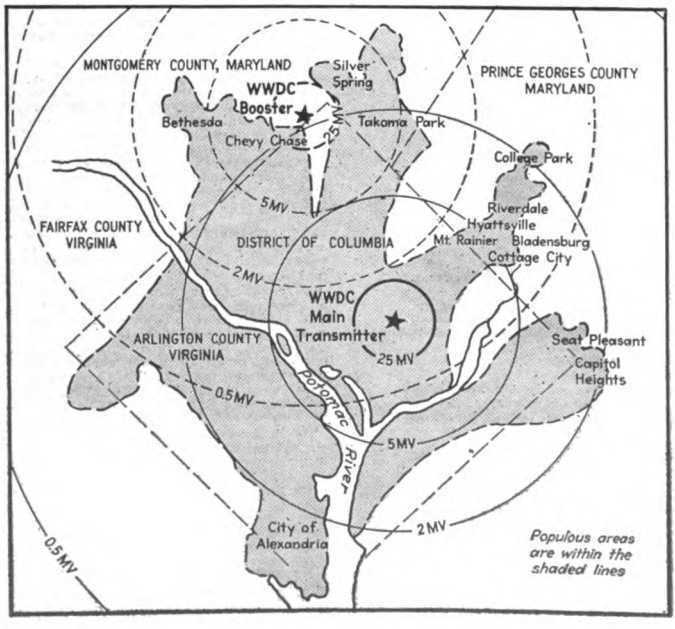

FIG. 1—Calculated field intensity contours of the WWDC main transmitter (solid lines) and booster transmitter (dash-dash lines)

How Boosters Function

Basically, an r-f booster as referred to here is nothing more than a linear amplifier receiving excitation in the form of modulated r-f power from the main transmitter and reradiating this signal by means of a suitable antenna system in an area in which the main transmitter field requires reinforcement. The difference between this and earlier work done in the synchronization of broadcast transmitters (WBZ and WBZA) is that an r-f booster has no oscillator or other frequency-generating apparatus and no modulators. It is automatically synchronous due to the fact that it receives excitation voltage from the output of the main transmitter and does not require modulation since this signal is already modulated.

From a practical standpoint the booster amplifier, antenna coupling unit and radiating antenna can be conventional in every respect, the only special consideration being that the booster amplifier be linear and very low in noise and distortion percentage. To accomplish this, all stages should be operated as closely to class A as is practical considering the power output requirements.

Methods of Feeding Boosters

Since the booster transmitter must be a linear amplifier and has no frequency-generating apparatus, some means must be provided to deliver a sample of the modulated r-f output voltage from the main transmitter to be used as excitation voltage at the input of the booster amplifier. This can be done by land

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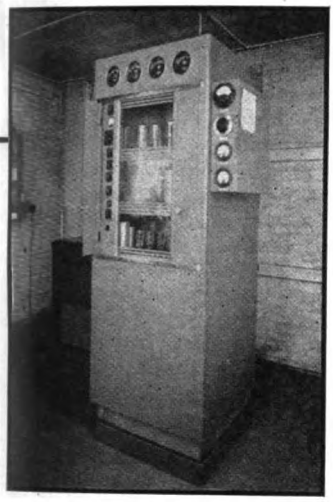
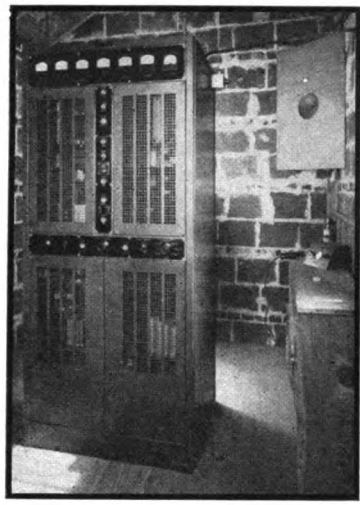
Satellite Transmitters





Left — WWDC main transmitter, with booster control panel mounted on the right side of the cabinet

Right—WWDC booster transmitter, unattended and operated by remote control from the main station

lines extending from the main transmitter to the booster or by space transmission whereby the signal from the main transmitter is received at the booster with a directional receiving antenna. A third method that has been suggested is modulation of a high-frequency relay transmitter with amplitude-modulated r-f voltage at the main transmitter, with subsequent demodulation by a receiver at the booster end. With suitable amplification this signal could then be reradiated to supply reinforcement to the main transmitter field. There is some question as to the practicability of this method due to the wide channel required for the relay transmitter.

Proposed UHF Links

Many standard broadcast stations now operating, except those on clear channels, have areas where the signal-to-noise ratio could be improved or interference conditions alleviated, through the use of unattended satellite transmitters, according to Howard S. Frazier in testimony given recently before the Federal Communications Commission and abstracted here:

"Prior to the development of ultrahigh-frequency techniques, the use of satellite transmitters has not been general due to the complexities of the equipment usually employed for the interconnecting control circuit and the economic factors involved. However, it is now believed practical to provide the connecting circuit between the controlling standard transmitter and the unattended satellite by the use of ultrahigh-frequency radio channels.

"It is proposed to use a very small portion of the antenna carrier current from the controlling transmitters for the double-sideband amplitude modulation of the high-frequency transmitter. The audio program would be present as secondary modulation. At the unattended satellite a high-frequency receiver would eliminate the high-frequency component and the resultant broadcast-frequency carrier would be amplified in order to drive the antenna of the satellite. It is proposed to use highly directive antennas with both the transmitter and the receiver.

"Equipment for this service should be inexpensive and not complicated from a technical standpoint. Some manufacturers have already had experience with equipment of this type in connection with other services. It is recognized that the location of satellite transmitters should be based on sound engineering practice and that the location of the satellite and the amount of power radiated should be such that mush areas would be reduced to a minimum and would occur in areas where few listeners are located."

WWDC Booster Uses Land-Line Feed

In the case of WWDC, land-line feed is used exclusively. Original calculations showed that if the main 250-watt transmitter were located in the business area of downtown Washington, the field strength in Northwest Washington, Chevy Chase, Maryland and Silver Spring, Maryland would be inadequate for proper coverage. It was obvious that the booster should be located near this area and a site was selected common to these points, approximately half-way between Silver Spring and Chevy Chase and just off the East-West Highway.

Then came one of the problems of this installation, routing of the r-f feed line from the main transmitter to this point. It was simplified to some extent by the availability of Western Union telegraph pole facilities along the B & O railroad right-of-way from the Washington Terminal to Silver Spring, a run of slightly more than six miles.

From Silver Spring over to the booster site was around 2.5 miles and from the Washington terminus of the Western Union facilities to the site selected for the main transmitter was a little over one mile. The problem of covering this latter span was a little more complex since no overhead facilities were available from the main transmitter to the Washington railroad yards.

It was planned to construct a

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special open-wire transmission line on Western Union poles from the Washington railroad yards to the booster, following the B & O railroad to Silver Spring and then from there along East-West Highway on telephone line poles. This was arranged, but for the span from the main transmitter to the Washington railroad yards there was very little choice other than to use the underground cable facilities of Western Union. This was a standard No. 19 gage 26-pair lead cable of which the majority of the pairs were already in use by Western Union.

No special treatment was given the cable other than to select the best available pair after noise and leakage tests were made on the pairs open for use. The length of this cable is 7,762 feet and, surprisingly, the loss along this portion of the line is less than would normally be expected at this frequency (1450 kc). To date no difficulty has developed due to induction or cross-modulation effects.

The open-wire portion of the line consists of 8¾ miles of No. 9 copper wire spaced 10.25 inches apart, presenting an approximate impedance of 700 ohms. The twisted pair in the lead cable measures 170 ohms at this frequency.

The loss in the entire line, which is over 10 miles long, is around 97 db. Approximately 29 watts is fed into the line from the final stage of the main transmitter, with approximately 2 millivolts being received at the booster end.

Coupling of the line to the main transmitter is accomplished by means of a variable capacitance which also provides a means for varying the amount of power fed into the line. A suitable matching transformer is used to couple the 170-ohm cable pair into the 700-ohm open wire transmission line. At the booster end, the line is terminated into a 700-ohm network, the output of which is link-coupled to the first stage of the transmitter.

Booster Amplifier Design

A modified Western Electric model 310B transmitter serves as the booster amplifier. The oscillator stage was removed and the coupling, the loading and the bias voltage of each succeeding stage was adjusted. Each stage was operated as closely to class A as possible while still obtaining the required 100 watts power output from the final with the excitation voltage available from the line. All stages are essentially class A with the exception of the final, which is class AB. In addition, a tuned circuit was substituted for the grid resistor in the first r-f stage to give better coupling in the phasing network, and avc w added to the first stage to compe sate for minor variations in excit tion voltage.

For an audio monitor, the mod lation amplifier was utilized a now supplies power not only to t monitor speaker but also to a li extending to the main transmitt for monitor purposes. The fin stage is coupled in a convention manner to a 150-foot Lehigh towe

Figure 1 shows the calculate contours of both the main an booster transmitters. Measur ments have shown, however, th the radiation efficiency of th booster antenna is not quite a great as calculated due to a limite ground system.

Remote Control Equipment

The entire WWDC booster plan is operated by remote control, a shown in Fig. 2. This is accom plished by means of three tele phone circuits and a small r- amplifier which is bridged acros the main r-f transmission line an operates time-delay relays for th filament and plate switches. On pair of lines is used alone for th audio monitor circuit and the othe two pairs are used in duplex with samples of plate current, plat voltage and antenna current ap- pearing on duplicate meters at the main transmitter. The excitation voltage to the booster is controlled by variation of the input to the transmission line at the main transmitter.

The r-f amplifier circuit that controls the filament and plate switches is shown in Fig. 3, and is designed to actuate the filament switch relay immediately upon arrival of an r-f signal from the main transmitter over the transmission line. The plate switch relay operates approximately one minute later. These relays drop out when excitation voltage is removed from the line, thereby removing the possibility of the booster transmitter remaining on in case of line failure.

The r-f carrier signal arriving over the transmission line is amplified by VT_1. Tube VT_2 is biased to cutoff, hence its plate circuit relay is inoperative with no carrier.

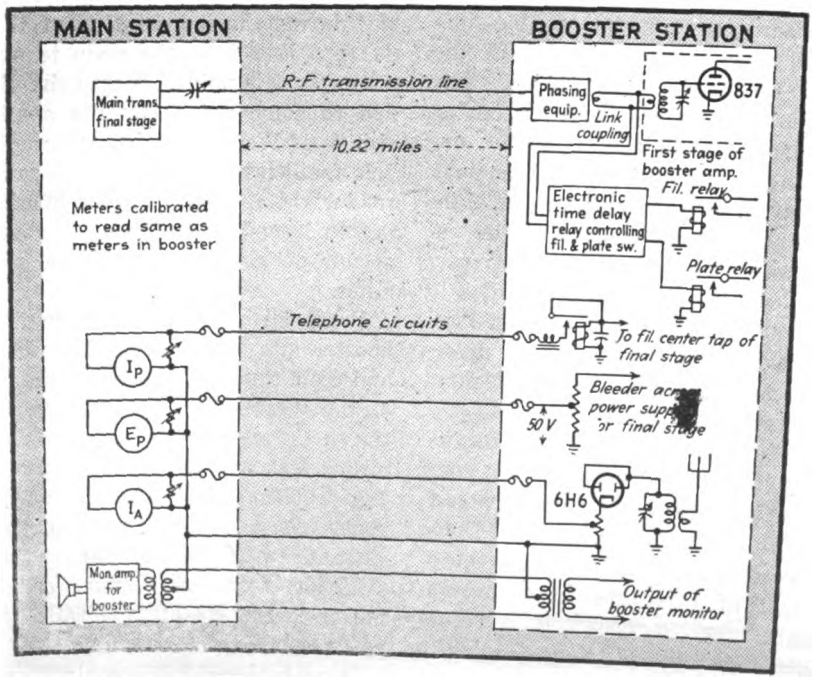

FIG. 2—Remote control system for WWDC booster transmitter

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arrival of the carrier overcomes the bias, making relay *1* operate and close the filament supply relay in the booster transmitter. Tube VT has a high negative bias when relay 1 is open (no carrier), amounting to half the plate supply voltage or 125 volts. Closing of relay 1 (on arrival of a carrier) shorts the resistor providing this negative bias, allowing the charge on the grid capacitor to leak off through the grid resistor to the point where *VT*, draws enough plate current to operate relay *2* and apply plate power to the booster transmitter. The time delay of the grid circuit is made sufficiently long to permit heating of tube filaments.

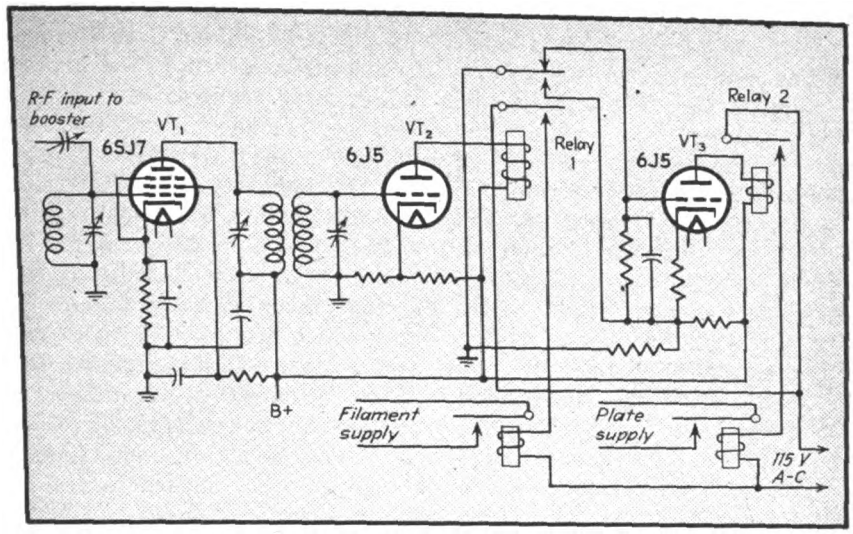

FIG. 3—Circuit of amplifier developed by C. R. Shaffer, Technical Supervisor of WWDC, to apply power automatically to the booster transmitter when a program signal arrives over the r-f transmission line from the main station

Space Transmission Method

The booster system originally installed at WINX, Washington, D. C., is an example of the method wherein the booster receives its signal through space rather than over wires. As with WWDC, original calculations showed that signal reinforcement would be required in Northwest Washington if the transmitter were to be located in the downtown area. A site for the booster transmitter was selected in an area approximately four and one half miles from the main transmitter, where the field from the main transmitter was calculated to be 2.5 millivolts. Later measurements proved this to be correct.

At the booster site, two receiving loops are oriented and phased to give a unidirectional pattern. The output of the loops is fed through a phasing network to a preamplifier consisting of two voltage stages and one 802 power stage. The output of this amplifier is then fed into a quarter-inch concentric line extending to the booster amplifier approximately 300 feet away, as shown in Fig. 4. At this point the line is terminated in another phasing network, the purpose of which is to synchronize the booster output with the main transmitter signal.

The WINX booster amplifier is of composite construction and has two stages—an 828, class A, driver two 203A tubes operating as class B, designed for 50 watts output. This is coupled to the antenna in a conventional manner. The antenna itself is novel, consisting of a 125-foot brick smoke stack encased with four copper leads suspended from the top and bonded together top and bottom.

The booster amplifier is operated by remote control from the main station, as shown in Fig. 5. Four pairs of standard telephone wires are used in this control circuit. One pair provides a monitor circuit. Another pair actuates a reversible stepper relay to control the r-f input to the transmitter and with the third and fourth pairs also serves to read samples of plate current, antenna current and plate voltage and to operate the main power switch to the transmitter. This latter circuit is so arranged that the transmitter automatically shuts down in case of failure of the control circuit.

Closing the toggle switch at the main station actuates relay *1* at the booster station through telephone line *1*, applying power to the booster transmitter and associated equipment. Lines *2* and *3* serve as return circuits for the remote plate current and antenna current meters when not in use as relay control circuits. Operating pushbutton *1* closes relay *2*, making the stepper relay rotate one step in one direction and moving the arm of a potentiometer that controls the r-f output from the loops. Releasing and again depressing this pushbutton repeats the action. Pressing pushbutton 2 closes relay 3 and causes the potentiometer to move in the opposite direction. The excitation voltage fed to the booster transmitter by its pickup loops can thus be controlled remotely by operation of pushbuttons 2 and 3 at the main station.

Lines 4, 5 and 6 carry samples of plate current, antenna current and plate voltage to the remote meters located at the main station. The booster monitor loop is excited by a portion of the booster monitor output and is terminated into the monitor system at the main station.

Design of Pickup Loops

The most interesting portion of the WINX booster system is its method of feed by means of a directional receiving array. This is accomplished by taking advantage of the natural bidirectional characteristics of the loops and also by introducing sufficient electrical phase difference in addition to the physical spacing so as to discriminate against signals arriving from the rear of the array.

The loops are spaced approximately 35 feet apart or roughly 15 degrees at this frequency, and are mounted about 30 feet above ground. The physical arrangement is such that the two loops are lined up in the direction of the main transmitter but are at right angles to the booster antenna. With this arrangement the natural null of the loops is presented to

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the booster antenna while the lobe of maximum pickup is in a plane with the main transmitter. Careful orientation gives rejection ratios between the main and booster transmitter signals of 10,000 to 1 or better. A rejection ratio of this order is critical and difficult to maintain, however, which is one of the principal objections to this system.

The physical dimensions of the loops are approximately two by four feet. They are constructed of two-conductor copper-shielded cable, with the two inner conductors cut and reconnected so as to form a two-turn loop. The outer shield is cut at the top and acts as an electrostatic shield. In the case of WINX the two loops were connected in series and then connected through the above-mentioned phasing network to the preamplifier.

Comparison of Line and Loop Methods

In evaluating the advantages and disadvantages of the two methods of excitation for the booster transmitter it appears that neither of the above systems offers the ideal solution. In the case of the WWDC land line feed, where open-wire transmission line is used, weather conditions cause variable line losses which are sometimes difficult to compensate for. Also, the cost of such a line is usually greater than that of receiving equipment. A concentric line between the two transmitters would minimize weather effects and provide an ideal system in other respects, but the cost would generally be prohibitively high. The transmission line method does offer greater stability than the loop method, however, and also provides a simpler means of control over the input where remote-control operation is utilized.

When the loop system is located close to the booster radiating antenna, as in the WINX system, adjustments become critical. As an example, suppose the loop system is located within the 200-millivolt area of the booster transmitter, where the field from the main transmitter is 2 millivolts. The signal ratio of 100 to 1 in favor of the weak signal from the main transmitter, in order to provide a signal ratio of 100 to 1 in favor of the weak signal from the main transmitter, which is the approximate ratio required for satisfactory performance, a rejection ratio of 10,000 to 1 would be required for the loop system.

While such a rejection ratio is entirely possible with careful adjustment of a well-designed loop system, many variable factors appear which make it difficult to keep such a system in adjustment. One of the greatest disadvantages of this system, however, is the pickup and reradiation of interference caused by other stations operating on the same frequency.

If the loop system is located in an area where the signal strength from the main station is below that required to override all interference, then reradiation of interference becomes serious. In a two-loop array with outputs phased so as to approximate a unidirectional receiving pattern, interference is eliminated to some extent but signals arriving at a high angle cause a great deal of trouble. Also, signals appearing at approximately 45 and 135 degrees on each side of the main axis can and do cause difficulty. The advantages of the loop system lie in economy of installation and elimination of long-line maintenance.

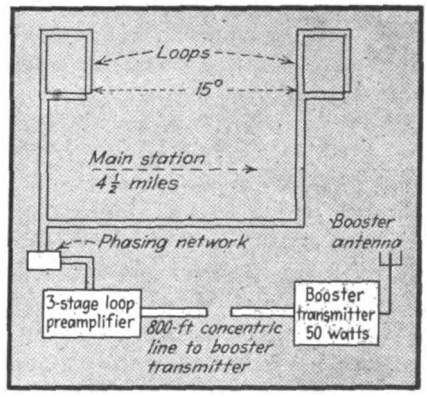

FIG. 4—Block diagram of WINX booster system, which obtains its r-f signal through space with a pair of loops beamed at the main transmitter

Possibly the best practical method of feed would be a combination of the two systems whereby a single loop is located in a heavy field from the main transmitter, at some distance from the booster transmitter, and connected with the booster transmitter means of telephone cable or, if sible, concentric line. This sh greatly reduce the interfere problem, reduce the cost of line stallation and also materially crease the stability of the loop tem due to the increased dista between it and the booster tra mitter.

Control of Mush Areas

The principal disadvantage w any booster station is the result mush areas. They are not limi to areas between the two transm ters, and are dependent to a gr extent upon the ratio of the pov output of the booster transmit to the power output of the m transmitter. In some cases, wh the power ratio is considerably favor of the main transmitter a where no phasing network is u ized to put the two signals in st at points beyond the booster tra mitter, the mush areas may co pletely surround the booster a will appear at any point where t two signals are of equal intensi and displaced as to phase.

It is not essential that the ma and booster transmitters be ope ated in phase, but in most cas better results can be obtained wh they are. Inphase operation used at WWDC and WINX, elim nating mush areas beyond t booster. Generally speaking, wh the booster output is low in cor parison to that of the main tran mitter and the booster is locat in an area subject to high absor tion (as with WSAI), mush are will completely surround t booster if phasing is not used.

Selection of the power ratio important in that it provides means by which the mush area can be controlled to some exten If care is exercised in the selectio of this ratio, the mush areas ca be made to fall, for the greate part, in predetermined areas whic in some cases may be thinly popu lated or in some way not so desir able from a coverage standpoin as others. There are other factor involved in making this determina tion, such as variable soil conduc tivity between the two transmit ters and the efficiency of the tw antennas, but with normal antenna efficiency in each case, the actual

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...ut of the two transmitters will ...e dominant factor.

Causes of Distortion

...ush areas are roughly a half ...elength wide and are found at ...nts at which the main and ...ster transmitter signals are of ...l or nearly equal intensity and ...e opposite in phase. In these ...as, cancellation or partial can...ation of the two signals occurs ...d the resultant appears as a con...derably weakened signal accom...ied by distortion of the audio ...ponent. The amount of dis...tion is dependent principally ...on (1) distortion introduced by ...e booster amplifier, and (2) dis...tion occurring as a result of ...ase differences between the two ...-f signals.

Distortion occurring as a result of the first case can be partially controlled by careful design and adjustment of the booster amplifier, and will considerably reduce the mush area. For example, assume a theoretical amplifier completely free of distortion. With such an amplifier the modulated r-f excitation voltage would be reradiated from the booster antenna with no change in the wave form other than an increase in amplitude. With an exact 180-degree phase displacement at a point of equal field intensity from the main and booster transmitters, complete cancellation of the two signals would occur. Still assuming 180-degree phase displacement, at any point other than one in which the two signals are exactly equal there would be a weakened signal but no distortion of the audio component.

Now consider the practical case where some distortion is introduced by the booster. In this case the two r-f envelopes are not the same and only that portion of the booster signal which originated with the main transmitter will be cancelled, leaving the distortion to appear as a small but greatly overmodulated r-f signal. The amount of this distortion will to a great extent control the width of the over-all mush area since for every half-wavelength, where the two signals are approximately equal, there will be cancellation to the extent that they approach each other in amplitude.

If the distortion present is small in comparison to the resultant signal, then the mush areas will be small and sharply defined. Under normal circumstances mush areas tend to disappear when the ratio between the two signals is of the order of 2 to 1 or more. If the distortion percentage is large, however, the area over which this condition will be noticeable will be increased proportionately. This is important, since by maintaining the booster transmitter with as low a percentage of distortion as is practicable, the area over which this condition is prevalent can be reduced to a minimum.

Phase Considerations

In the above, only the half cycle which was exactly out of phase with the main transmitter signal has been considered. The following half cycle, due to the two signals traveling in opposite directions, will be in phase and the two voltages will add, causing no particular difficulty.

The above analysis also assumes an exact 180-degree phase displacement. This would occur normally only on a straight line between the two transmitters (or on this same line extended beyond either transmitter if phasing equipment is not used) and not necessarily at a point of equal signal intensity.

It is not likely that any point could be found at which complete cancellation of the two signals occurs, because when they are equal in amplitude they are generally not exactly 180 degrees out of phase. At any point off this theoretical line, the phase angle between the two signals becomes less than 180 degrees. At such points and along the line of approximately equal signal intensities, phase distortion of the modulated r-f envelope is most apparent and results in a distorted audio component. This is by far the most serious of the causes for mush areas since no method of control has yet been devised. No amount of phasing equipment will put the two signals in phase at all points between the two transmitters.

Conclusion

In summation, it may appear that a negative viewpoint has been adopted as to the use of boosters due to the mush areas involved. On the contrary, it is felt that amplifiers of this type may in many cases be the solution to the dead spot and interference problems of many broadcast stations. Actually, mush areas cover only a very small percentage of the service area of a station and in many cases these can be made to fall in areas not considered of great importance from a coverage standpoint. The additional service rendered by such an installation greatly offsets any disadvantage occasioned by its use.

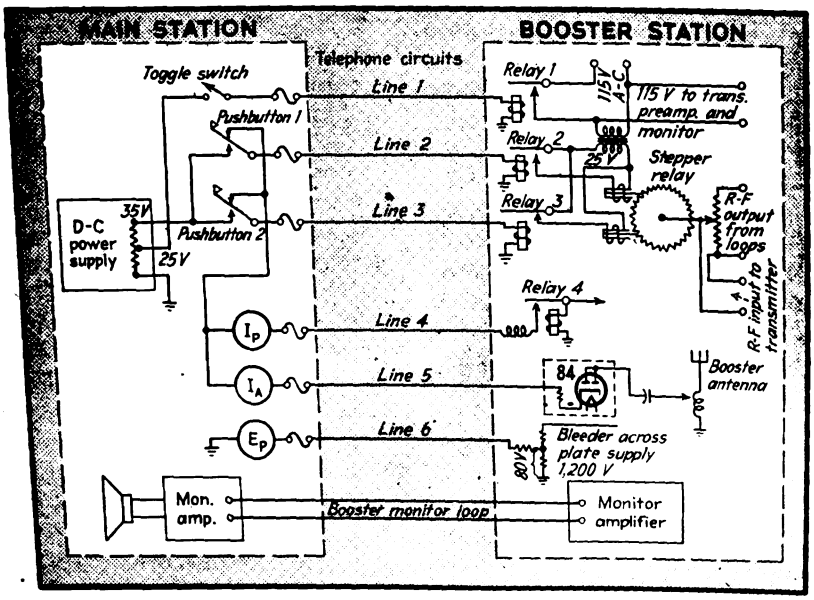

FIG. 5—Remote control system for WINX booster transmitter, using four pairs of standard telephone lines. Relay 4 connects line 4 to the high side ... overload relay in the filament center-tap of the final st

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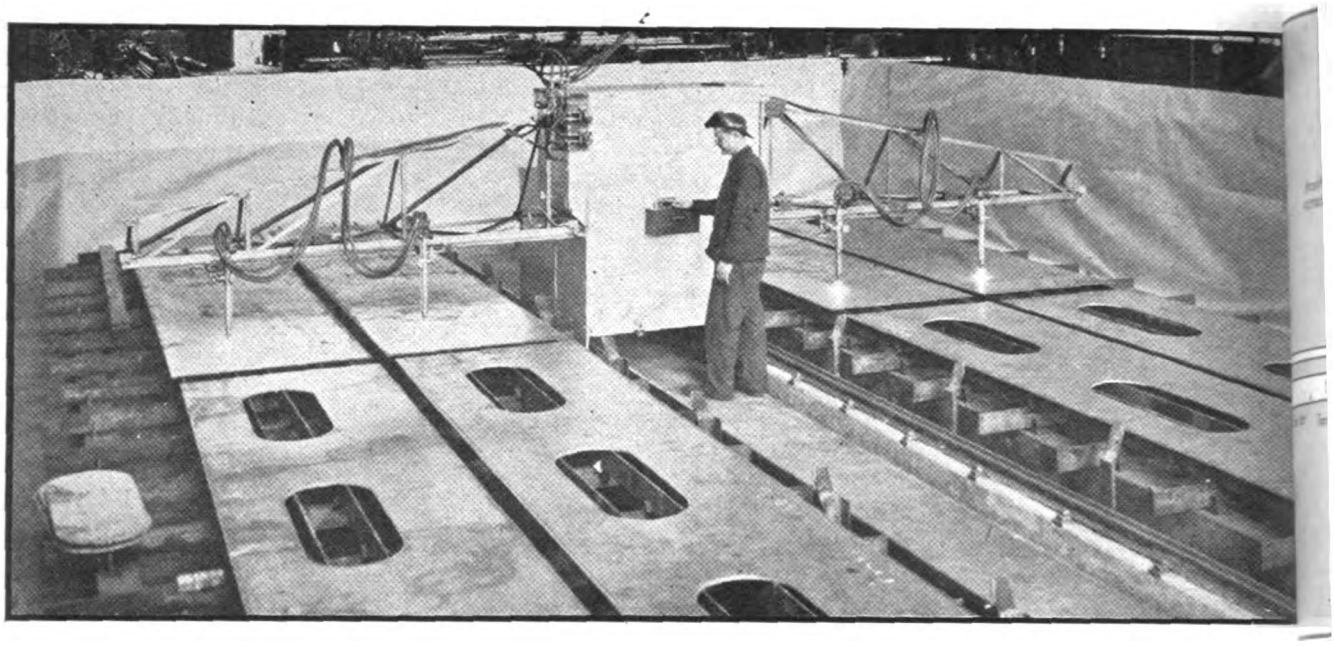

Four-torch electronically positioned flame cutter being used to cut weight-reducing holes in girder frame members for a rayon spinning machine. The torches have already completed cutting of the four pieces in the foreground, and have accurately trimmed all four edges of the pieces about to be perforated

Phototube-Controlled

Electronic control makes possible accurate oxyacetylene cutting of large steel sheets on a mass-production basis, using photoelectric scanning of small master drums in place of conventional contour tracing of costly full-size master patterns

By DAVID S. WALKER
Chief Engineer
Industrial Scientific Co., New York

AUTOMATIC control in oxyacetylene flame cutting of steel shapes on a mass-production basis is achieved with the ISC flame cutter by using electronic control. The flame cutter has been in continued use in shipyards and machine fabrication plants for over three years. The system utilizes photoelectric control in a unique manner that eliminates the follower or outline-tracer requiring full-size templates.

Templates for flame cutting by commercially developed follower or manual tracer systems are full size, some being more than seven feet wide and thirty feet long. Fabricating, repairing and storing such templates is quite expensive and requires a great deal of floor space.

Four Drums Guide Cutters

The outline to be cut by the electronic flame cutter is determined by markings or reflecting spots on four black Bakelite drums, shown in Fig. 1. Two of the drums control the action of the longitudinal drive motor, and the other two control the transverse drive motor. One set of four drums has sufficient space for controlling the actions of the machine to between 100 and 200 lineal feet of cut. The available cutting length on one set of drums may be used to make up the control for one large piece to be cut, or for several smaller shapes. The changeover from cutting one shape to another on the same drum is accomplished by setting the drums manually so that the phototube scans the proper section of the drum.

Changing record drum sets is simple. Each drum is set-screwed to its holder. Unloosening the set screws allows the drums to be removed and the new set to be placed on the holders. Drums do not wear out, as scanning with a light beam eliminates any surface wear on the records. The drums are lightweight paper-base phenolic cylinders with a dull black surface.

Operating Principle

The method of operation is based on the resolution of any shape into its Cartesian coordinates. Considering longitudinal cuts as being along the Y axis and transverse cuts as being along the X axis, any cut along a diagonal is determined by its projection on both the X and Y axes. Longitudinal movements are controlled by one distance drum

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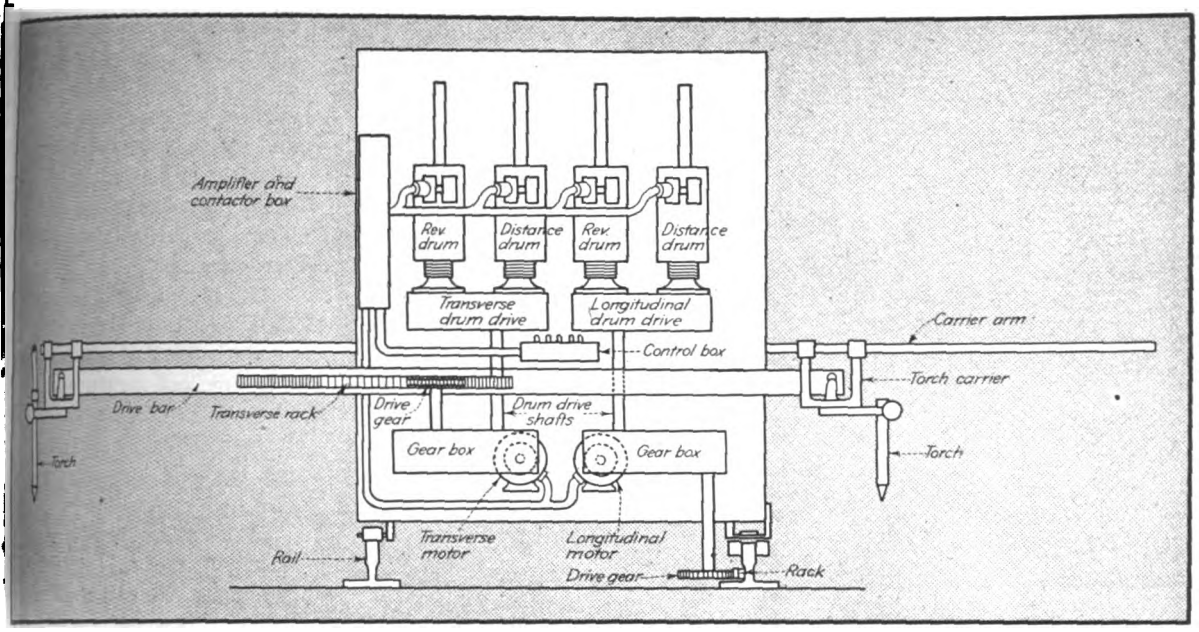

Sketch showing relationship of major elements of the flame cutter. Additional torches may be added, for simultaneous cutting of four or more pieces. On large, intricate shapes requiring high accuracy, it has been found economical to prepare master drums for production runs as small as 12 pieces

Flame Cutter

and one reversal drum, and transverse movements are controlled by the other two drums. As an illustration of how the drums control the movement of the cutting torches, when the two longitudinal drums are black the torches may be moving longitudinally in one direction and cutting a straight line. Arrival of the scanner at a white dot on the longitudinal distance drum stops the longitudinal drive motor and starts the transverse drive motor. Now if the scanner on the transverse distance drum reaches a white dot soon, the transverse motor stops and the longitudinal motor starts again in the same direction as before. Repetition of this process at equal very short intervals gives a zig-zag torch motion corresponding to a cut on a straight line at 45 degrees, while unequal and varying intervals produce torch motion along curves. Arrival of either of the reversal scanners at a white area causes the corresponding motor to travel in the reverse direction thereafter.

All four drums are inscribed simultaneously with jeweled styli by a step-by-step process while the scribing machine is tracing a sample of the finished product, and the controlling markings are later filled in with white ink to make them light-reflecting. In describing a curve or diagonal cut, intervals are taken to most nearly approximate the instantaneous ing curves, the

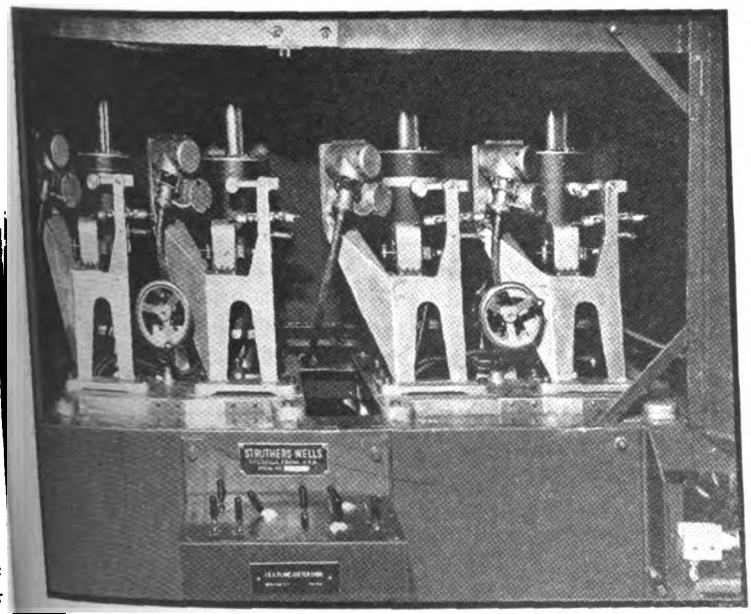

FIG. 1—Control drums and scanning heads of the flame cutter. Longitudinal and transverse travel drums have many white reflecting dots in this setup, for cutting curved objects. The drive motors may start and stop as often as 100 times per minute. The two reversing drums have relatively large alternate areas of black and white

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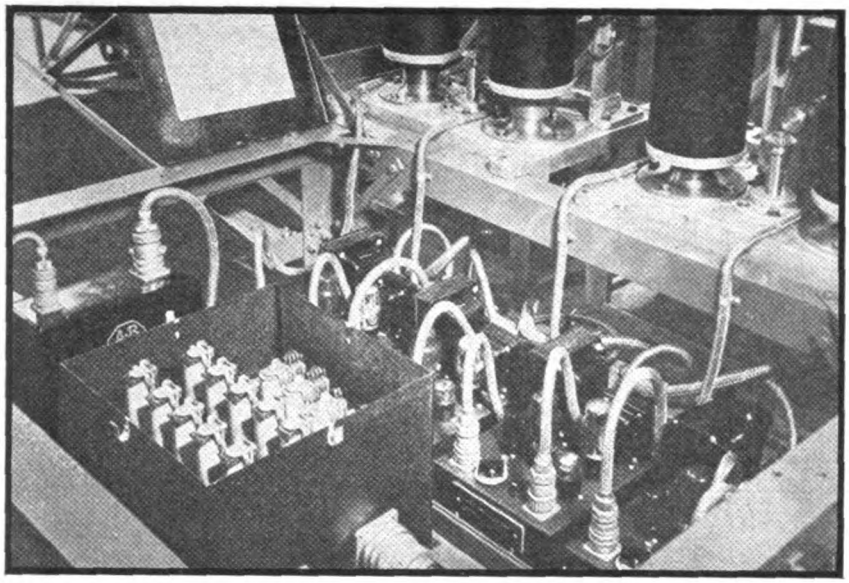

View of the four amplifiers and the relay box, with master drums in background

very small in order to follow faithfully the instantaneous slope, while in straight-line cuts the interval may be of any desired length.

Scanning Apparatus

The photoelectric pickup units are in cast aluminum housings. Each exciter lamp and its associated optical system projects a small spot of light on its drum. The reflecting surface allows a large part of the incident light to be reflected onto the cathode of the phototube. The system employs accurately ground lenses in both projector and pickup units so that there is in practice no interference from stray light.

Control impulses from the four scanners go through low-capacitance cables to four amplifiers which are of the direct-coupled type, as the machine must operate equally well at very low speeds and at speeds in excess of 24 inches per minute. Control frequencies range from zero to 100 square-wave cycles per second.

Amplifier Circuit

Each amplifier circuit utilizes a 921 phototube feeding into a 6SJ7 amplifier which in turn is directly coupled to a 6V6 output tube driving a telephone-type d-c plug-in relay, as shown in Fig. 2. One type 80 and one type 6H6 form the powe[illegible] Line voltage regulati[illegible]d to minimize variations in supply voltage. The 921 phototube has its cathode grounded, necessitating an additional voltage supply. The few extra components needed for the additional supply are more than justified by the higher frequency response due to comparatively low anode-ground capacitance. Polarizing voltage on the phototube and plate voltage of the 6SJ7 are both 80 volts. This value is well under the ionization potential of the gaseous type cell, insuring fairly constant response with the wide variations in cell temperature. The low plate voltage also achieves good voltage sensitivity on the 6SJ7; a very small negative grid voltage will completely cut off the tube.

The 6SJ7 actually operates very near to zero bias with no light on the phototube, with potentiometer R_4 taking care of variations in dark current when replacing the phototube. Thus, when no light falls on the phototube there is minimum bias on the 6SJ7 and maximum current flows in the first amplifier plate circuit. Light falling on the phototube anode decreases its internal resistance, allowing more current to flow, and produces a voltage drop in resistor R_1 which is both phototube load resistor and amplifier grid resistor. The resultant negative bias cuts off the 6SJ7.

The sharp cutoff characteristic of the 6SJ7 and the low plate operating voltage together allow considerable latitude in bias for c[illegible] off. Since the amplifier serves as sensitive switch with no linear [illegible] sponse necessary between outp[illegible] and input, wide variations are p[illegible] missible in bias setting, phototu[illegible] sensitivity, line voltage and excite[illegible] lamp output without influenci[illegible] performance.

The plate current of the 6SJ7 thus seen to be always either ze[illegible] or the value corresponding to ze[illegible] bias for load resistor R_2, which also the grid resistor for the 6V[illegible] In controlling the 6V6, overswin[illegible] ing the grid insures stable oper[illegible] tion.

If the phototube is dark, curre[illegible] flows in the 6SJ7 plate circui[illegible] causing a voltage drop in R_2 whic[illegible] in turn cuts off the 6V6. Co[illegible] versely, when light is incident o[illegible] the phototube, the 6SJ7 is cut o[illegible] and the plate current of the 6V6 i[illegible] determined by the plate voltage an[illegible] the resistance of the relay coil. [illegible] 10,000-ohm resistance value for R_3 limits voltage surges when th[illegible] magnetic field of the relay co[illegible] lapses.

Power Supplies

The direct-coupled amplifier a[illegible] described above has very goo[illegible] square-wave response, with th[illegible] upper frequency limit determine[illegible] principally by the inductance of th[illegible] relay used in the output circuit Well-filtered power supplies ar[illegible] necessary to achieve both the fas[illegible] action required of the relay and th[illegible] high sensitivity of the pickup.

The power supply for the output tube is a conventional full-wave rectifier feeding into an *L*-type filter. The other two power supplies in each amplifier are designed to take advantage of the low power drain required. A 6H6 is used in conjunction with a center-tapped winding on the power transformer to provide two independent, equal half-wave rectified voltages in series. Each voltage source has a filter comprising a 10,000-ohm resistor and two 8-μf capacitors. Total bleeder current, including capacitor leakage, is over 3 ma, while the 921 phototube requires only a few microamperes and the 6SJ7 a little over 1 ma. Resistor-capacitor filtering provides cheap, compact and dependable filtering in these ranges.

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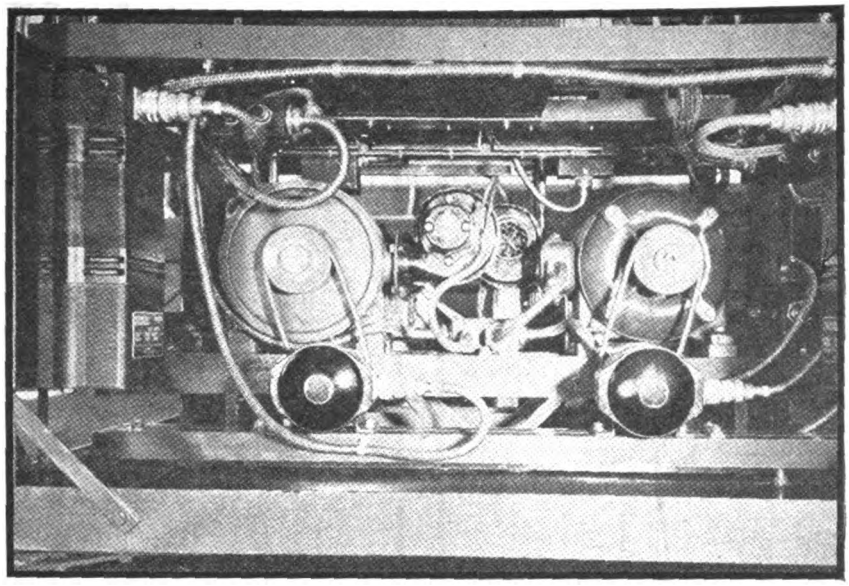
All amplifiers are interchangeable so that one spare amplifier is all that is needed to assure continued operation should any one of the four amplifiers in the machine become inoperative. Unplugging the two AN connectors of an amplifier allows it to be removed for inspection and the spare amplifier assures that there is no holdup in production. The power supply for all four amplifiers is so inter-connected that none will operate unless all four are plugged in.

The control impulses of the four d-c relays actuate the a-c telephone-type relays and their associated contactors in such a way that the required sequence of operations of the motors is achieved.

The final drive is through two specially designed three-quarter horsepower three-phase induction motors capable of making more than a hundred stops and starts a minute. Positive stopping without overtravel is assured by the use of plugging switches. The drive motors are coupled directly to the record drums and to the longitudinal and transverse racks so that the record drums always rotate in synchronism with the movements of the torches.

The torches travel in a transverse direction along arms projecting from the machine. Longitudinal travel of the torches is achieved by moving the entire machine on its rails.



Transverse and longitudinal driving motors. The voltage-regulating transformer at the left serves the a-c contactors and the amplifiers

The operator can position the torches electrically through lever switches provided. There is an interlock which cuts out all automatic functions while positioning.

When the torches are all lined up and the work preheated, the operator flips the lever to automatic operation. He need not touch the control box again until the entire piece has been cut, at which time he presses the stop lever. During all the intervening time he may give his full attention to the torches, regulating them so that the best cut is achieved. Up to sixteen torches may be used. Stoppages from torches blowing out are reduced not only because the operator can give them his full attention but also because of the uniform speed of cut.

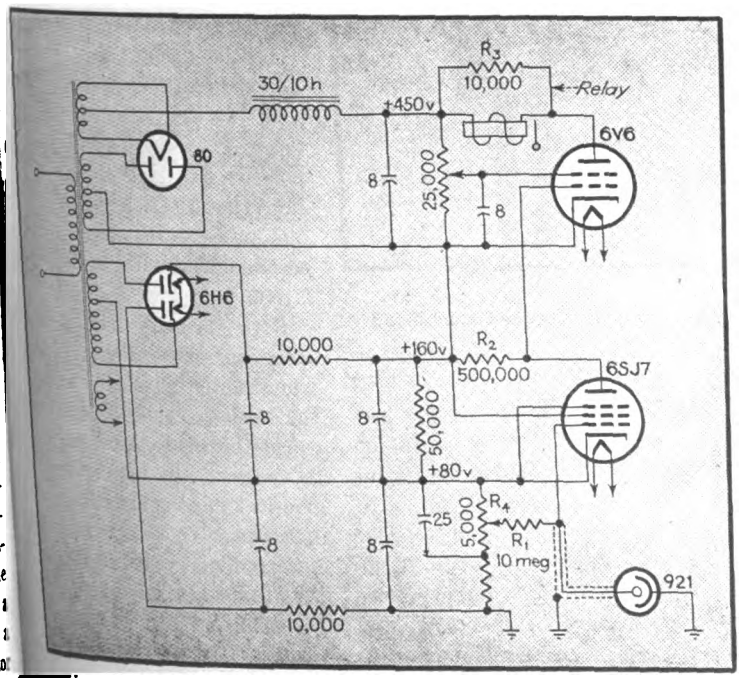


FIG. 2—Schematic circuit diagram of amplifier serving the phototube of one of the drums. All four amplifiers are identical. The output relay controls other contactors in the driving motor circuits

Maintenance is Simplified

Operation under mill conditions has proved the advantages of plug-in components, not only in reducing outage time but in the ability of plant men, unskilled in electronics or electrical controls, to make replacements themselves. It is no more difficult for them to replace a defective amplifier or relay than to change tubes in a radio.

The flame cutter has proven itself in operation to have many advantages over machines doing comparable work. It produces at least four times as much in cutting any given shape in comparison with other machines. Accuracy of cut is unequaled by any other method, as every movement, even to the smallest increment, is positively controlled. Operator fatigue is reduced to a minimum. Finally, electronic control gives unchanging record

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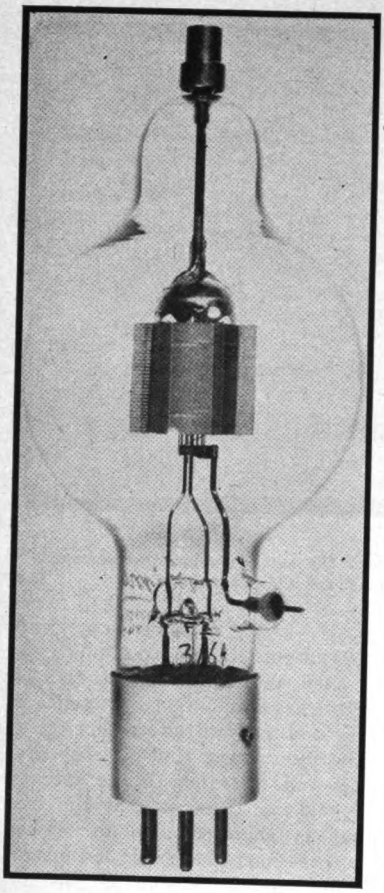
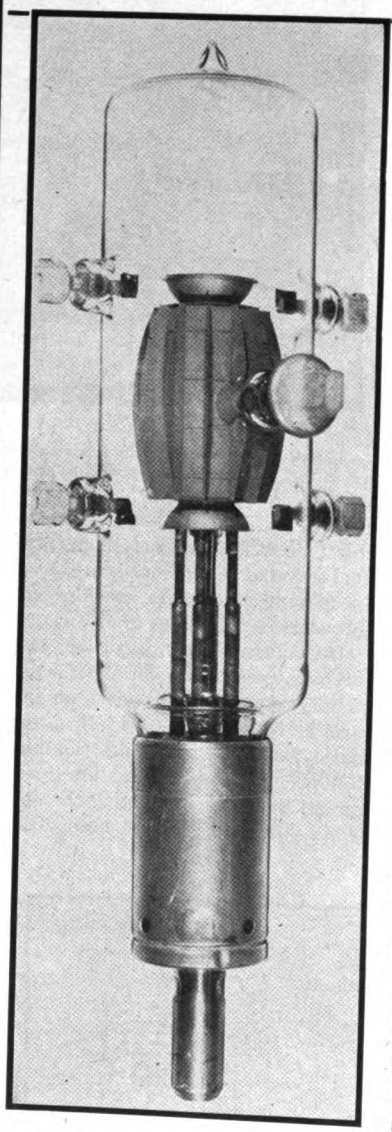
Grid Emission in



Eimac type 100T tube used as a guinea pig in many of the tests discussed here



Type 527 tube, employing an X-grid

THIS ARTICLE deals with the problem of electron emission from the control grid in a high-vacuum triode having a thoriated-tungsten filament. The specific type of cathode employed is early mentioned, because emission from the grid is directly tied up with the nature of the active material on the cathode. The remedy for grid emission in a tube having a thoriated filament, for example, is not necessarily the answer to grid emission troubles in a tube containing an oxide-coated cathode.

In its broader aspects the question involves the suppression of emission from an electrode whose normal function is best performed by selective emission, or no emission at all. The term selective emission is advisedly used because there can be two distinct kinds of emission from a grid: primary emission and secondary emission. Much confusion has resulted by failure to distinguish between these, and to identify their causes and effects. Since electrons leave the grid by both primary and secondary mechanisms, like effects under certain conditions would naturally be expected. That the effects are not always the same has led to one cause being mistaken for the other in a great many cases.

The primary electrons about which we are concerned are those emitted by reason of the fact that the grid runs at an elevated temperature; in other words, thermionic emission from grid. Grid heating in a power triode is caused by electron bombardment of the grid during its positive excursions, and also by thermal radiation from the filament and plate. Since primary emission from the grid is a function of grid temperature, such primary electrons as are emitted leave the grid continuously during operation of the tube. As with other continuous processes based on temperature, the effects are cumulative. This matter of continuity of emission is worth keeping in mind while distinguishing between primary and secondary emission from a grid. Mouromtseff and Kozanowski[1] describe a simple circuit for measuring primary emission.

Primary and Secondary Emission Effects

By definition, secondary electrons are those released from the grid under the impact of electrons originating from another source, such as the filament. Since the grid is bombarded when positive with respect to the filament, secondary emission occurs only during the positive half-cycle of the grid driving-voltage. Being a discontinuous process, the direct effects of secondary emission are not cumulative.

Both primary and secondary emission reduce the grid current when power tubes are operated in the positive-grid region, and may cause the grid current to reverse its normal direction of flow. In grid-leak bias circuits this results in a loss of bias, accompanied by increased plate current. The primary component of grid emission is the bad actor in this case, because a vicious circle is started. The increased plate current causes increased plate temperature, which in turn raises the grid temperature,

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Vacuum Tubes

Causes and effects of primary and secondary emission are discussed. Emission photographs of various materials, taken with an electron microscope, are presented. Tests which resulted in the development of a special grid are described

By HAROLD E. SORG and GEORGE A. BECKER
Director of Laboratory *Research Engineer*
Eitel-McCullough, Inc., San Bruno, Calif.

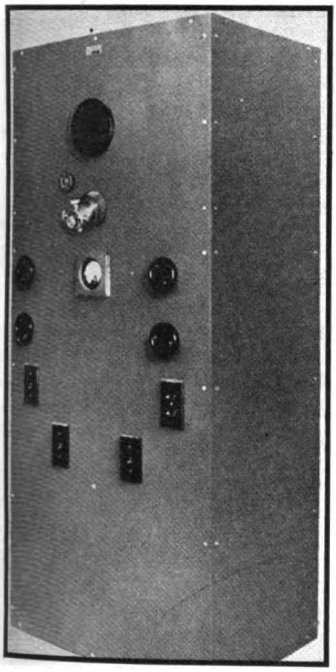

FIG. 1—Special electron-microscope developed to take emission photographs. The instrument is shown schematically in Fig. 2

causing further increase in primary emission from the grid. The effect is cumulative, and once the grid current starts to drop the grid may lose control, allowing the tube to run away.

The effects of secondary grid-emission are less obvious. Secondary electrons are emitted by reason of electron bombardment from the filament, which occurs only during the positive half-cycle of the grid driving-voltage. The effects are not cumulative and, if primary emission is under control, can be beneficial because the grid current is reduced and hence the grid driving-power lowered. This apparent something-for-nothing is frequently accompanied by instability of operation, however, the tendency toward dynatron-type parasitic oscillation being enhanced. The effects of secondary emission from a control grid may be summed up by saying that secondary electrons are beneficial if moderate, but can lead to instability if excessive. For practical purposes the ideal control-grid is one which exhibits no primary emission and negligible secondary emission.

Metallurgy Provides the Key

Several years ago it was recognized that unless a solution could be found for the grid-emission problem, a serious barrier stood in the path of power-tube development, where grid temperature is an important factor. While experimenting with high-vacuum tubes having thoriated-tungsten filaments and grids of refractory metals, such as tantalum and molybdenum, it was observed that primary grid-emission was materially increased by activation of the grid with thorium sputtered or otherwise deposited from the filament. After a period of operation these tubes were found to contain not only a thoriated filament but also a thoriumized grid. So activated, the grid developed primary emission.

A reverse phenomenon was also occasionally observed in the case of the filament. Some sort of contamination was reaching the filament, killing its emission. This was interesting. If something would poison the emission of a thoriated filament, why would't the same thing be good for the unhappily thoriumized-grid? With this key the search went on, resulting in the perfection of what is now known as the X-grid. Initial development work was done by Wil-

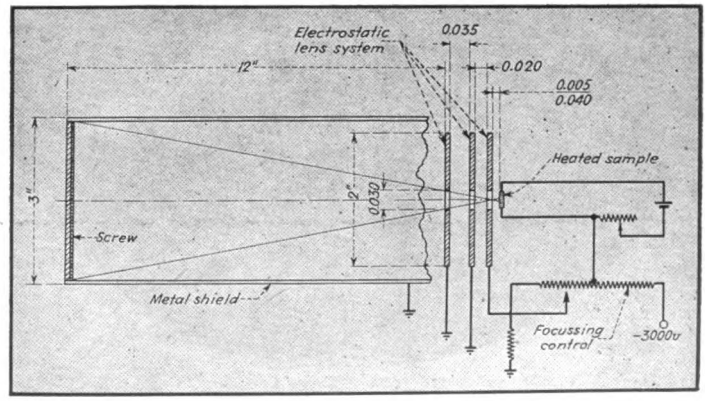

FIG. 2—Schematic of the special electron microscope pictured in Fig. 1

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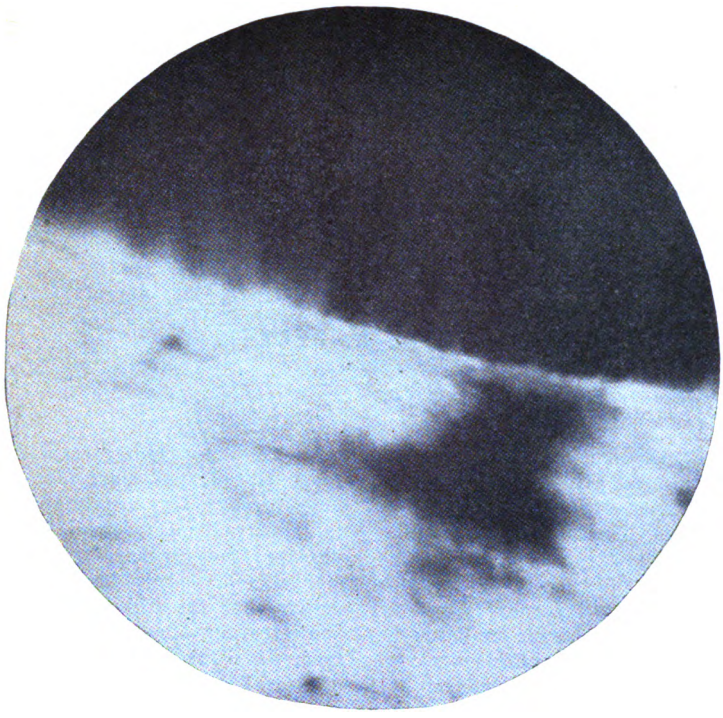

FIG. 3—Emission photograph of thoriated tungsten, taken at 1300 deg C. In this instance an edge of the sample was photographed, so that emission streamers are visible

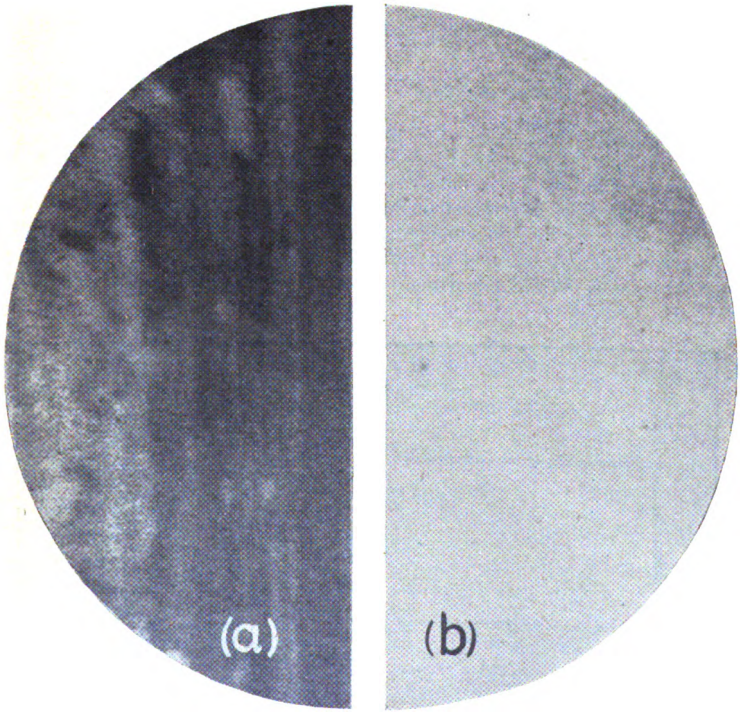

FIG. 4—(a) Emission photograph of pure tantalum, taken at 1500 deg C, and (b) at 1700 deg C. Half-photographs are shown adjacent to each other to conserve space and facilitate comparison

liam W. Eitel and Jack A. McCullough. While the X-grid was developed principally to overcome primary emission, it fortunately also exhibits a low order of secondary emission.

During the course of the investigation the emission properties of numerous metals other than tantalum and molybdenum were studied. Platinum has unique properties and deserves special mention. If properly handled in tube manufacture a platinum grid will exhibit little or no primary emission during subsequent life of the tube. Resistance of platinum to activation by thorium is apparently due to an absorption phenomenon. The principal disadvantages of platinum, aside from the element of cost, are its relatively low melting-point, its poor mechanical strength compared to the more refractory metals, and its relatively high secondary-emission properties.

Special Electron Microscope Used

Much of the subject work on grid emission was done with the aid of a special electron-microscope. Figure 1 shows a photograph of the complete unit and Fig. 2 is a diagrammatic view of the essential parts. This unit provides means for visual examination of electron emission from any desired metal, and the effects of contaminants thereon, at any desired temperature. For example, a specimen containing thorium can be mounted adjacent to a specimen of grid material, and the latter contaminated with thorium vaporized from the former. The emission properties of the contaminated grid material may then be studied. Emission patterns are directly observed on the screen. For later study and record purposes, photographs and even moving pictures can be taken of the specimens.

A series of emission photographs taken with the electron microscope are illustrated. (*Ed. Note:* All emission photographs reproduced here were originally taken at a magnification of 125. As reproduced, however, they represent a magnification of about 100.)

Figure 3 shows the emission pattern of ordinary thoriated tungsten. This photograph is included here

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merely because thoriated tungsten is a familiar type of emitter material and serves as a reference for comparison purposes. The photograph was taken with the specimen at 1300 deg C; all temperatures herein being brightness temperatures as indicated by an optical pyrometer. The light areas in the photograph are the actual traces produced on the screen by primary-electrons emitted from the sample, the darker areas indicating a lack of emission. This particular photograph happens to show an edge of the specimen, and the streamers present constitute electron emission from the edge.

Figures 4 (a) and 4 (b) show emission patterns of the surface of pure tantalum at 1500 deg C and 1700 deg C, respectively. Figures 5 (a) and 5 (b) show similar patterns of pure molybdenum at like temperatures. It is evident that tantalum exhibits somewhat higher primary emission than does molybdenum at a corresponding temperature. The pronounced increase in emission from both metals, for an increase of 200 deg C in the temperature region indicated, is worth noting.

Figure 6 shows the emission pattern of a sample of tantalum contaminated with thorium at 1400 deg C, the streamers visible being from an edge of the sample. The tremendous increase in primary emission seen in comparison with Fig. 4 (a) explains why a tantalum grid used with a thoriated filament often causes a tube to run away during operation. Molybdenum exhibits a similar increase in primary emission upon contamination with thorium. Curves in Fig. 7 illustrate the effects of this contamination in a tube.

Figure 8 shows the emission pattern at 1700 deg C of the surface of a sample of tantalum partially treated by the X-process. The lighter area at the left in the photograph constitutes the emission from the pure tantalum, and the darker area at the right indicates the absence of emission from the treated portion of the sample. Since the X-processed material is seen to have a lower order of primary or thermionic emission than either tantalum or molybdenum, one would expect it to have

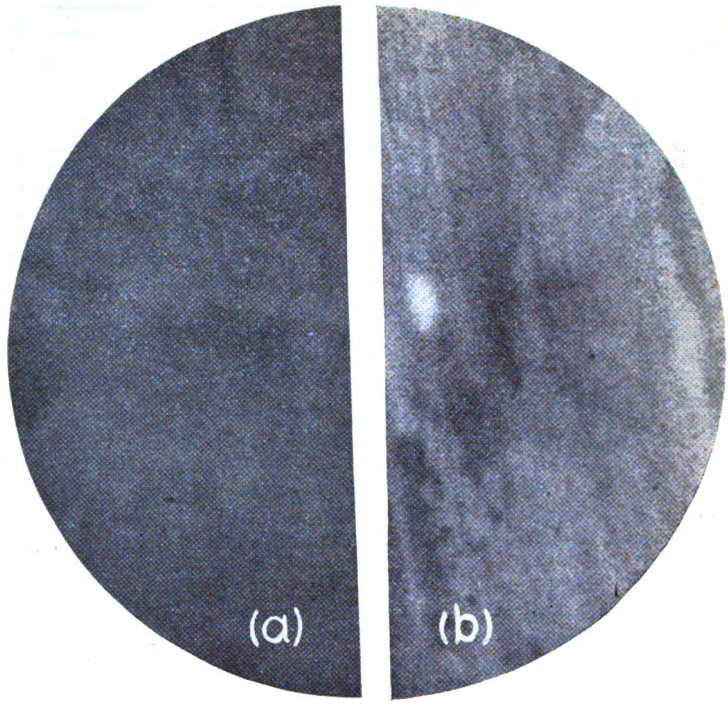

FIG. 5—(a) Emission photograph of pure molybdenum, taken at 1500 deg C, and (b) at 1700 deg C

FIG. 6—Emission photograph of tantalum contaminated by thorium, taken at 1400 deg C. The edge of the sample was photographed so emission streamers may be seen

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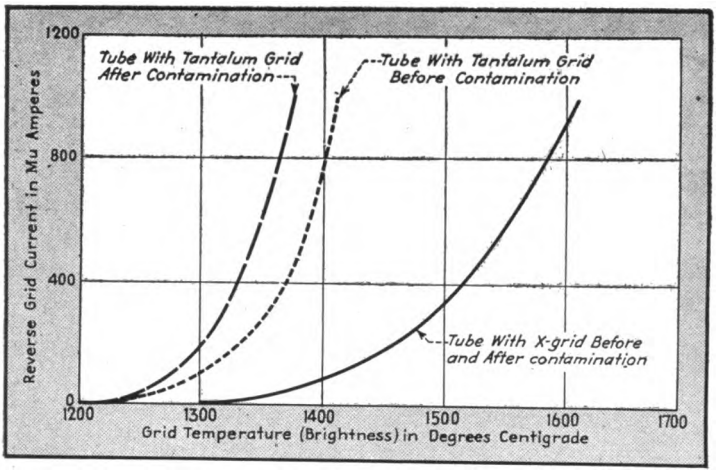

FIG. 7—Primary emission grid characteristics

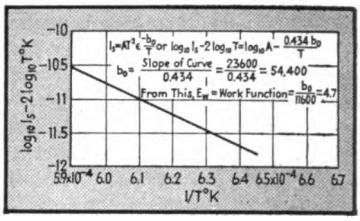

FIG. 9—Emission from a tantalum grid

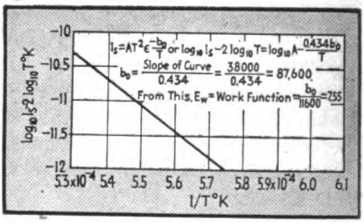

FIG. 10—Primary emission from an X grid

a higher work-function. Such is the case. Figure 9 is a plot of primary emission from tantalum, from which a work function of 4.7 is derived. This value compares favorably with that previously determined by others. A similar plot is illustrated in Fig. 10 for the X-grid material, from which a work function of 7.55 is derived.

Test Results

It is now interesting to observe what happens when the X-grid is contaminated with thorium. Figures 11 (a) and 11 (b) show emission patterns of the surface of X-grid material so contaminated, taken at 1700 deg C and 1900 deg C, respectively. These evidence a negligible increase in primary emission as compared with the pronounced increase exhibited in the case of contaminated tantalum. The ability of the X-grid to render thorium inactive is responsible for this improvement.

The solid-line curve in Fig. 7 shows that contamination of an X-grid in a tube does not increase its primary emission properties. By comparison with the dashed-line curve it will be observed that if .500 μa is taken as a safe value of primary emission, a tantalum grid must be operated at a grid temperature under 1350 deg C whereas an X-grid may be operated in excess of 1500 deg C. A more striking difference will be noted at a grid temperature of 1350 deg C, where the tube with the X-grid has a reverse grid current of nearly zero, while that with a contaminated tantalum grid exhibits a reverse grid-current of about 600 μa at the same temperature.

The secondary emission properties of the X-grid, compared to platinum for example, are illustrated by curves in Fig. 12, these curves being taken on two tubes having identical geometry. The

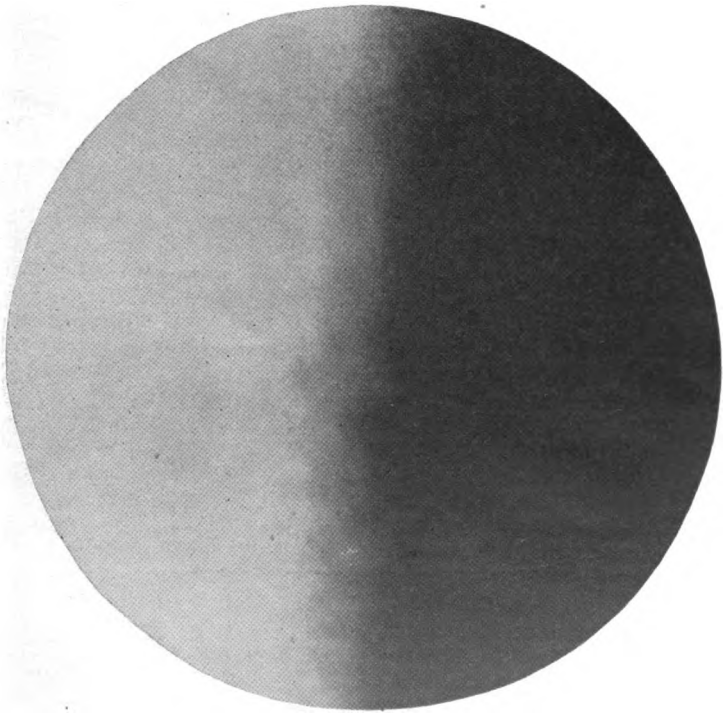

FIG. 8—Emission photograph of tantalum partially treated by X-process, taken at 1700 deg C. The left side shows the greater emission from the untreated portion, while the right side shows the reduced emission from the treated portion

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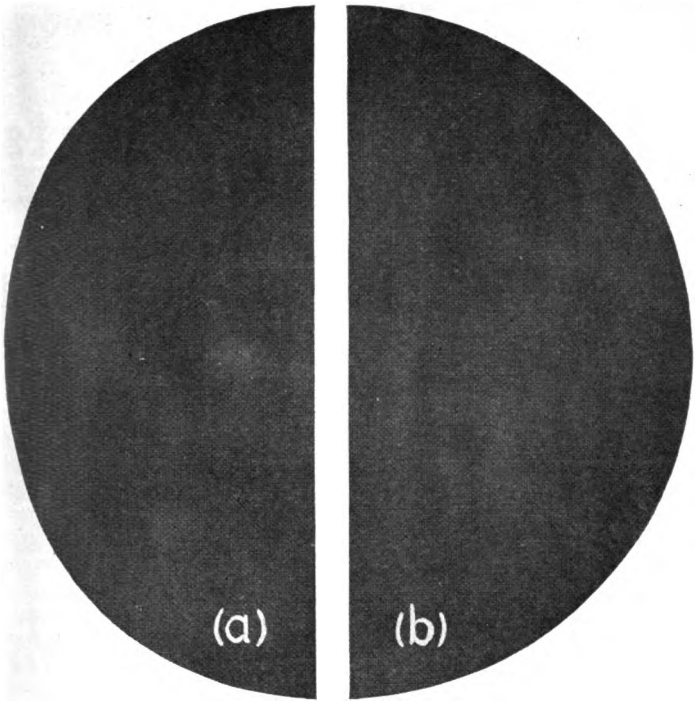

FIG. 11—(a) Emission photograph of X-processed material contaminated with thorium, taken at 1700 deg C, and (b) at 1900 deg C

higher order of secondary emission for platinum is indicated by lower values of grid current, which, for certain values of grid voltage in the tube used, actually become negative. Secondary emission shows up in constant-current charts as loops in the grid current lines. Figure 13 is a chart of a tube having a platinum grid. This can be compared with the chart in Fig. 14 on a tube of identical geometry, but having an X-grid, showing the absence of such loops in the grid-current lines.

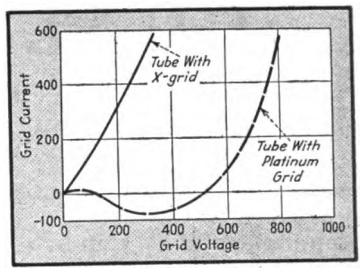

FIG. 12—Secondary emission characteristics, both tubes under test having identical geometry and operating with 2500 volts on their plates

It is apparent that operation along a load line passing through the region of negative values of grid current would give a distorted wave of grid current, sufficient to cause instability and parasitic oscillations.

References

(1) Mouromtseff, I. E., and Kozanowski, H. N., Grid Temperature as a Limiting Factor in Vacuum Tube Operation, *Proc. I. R. E.*, 24, p. 447, March, 1936.

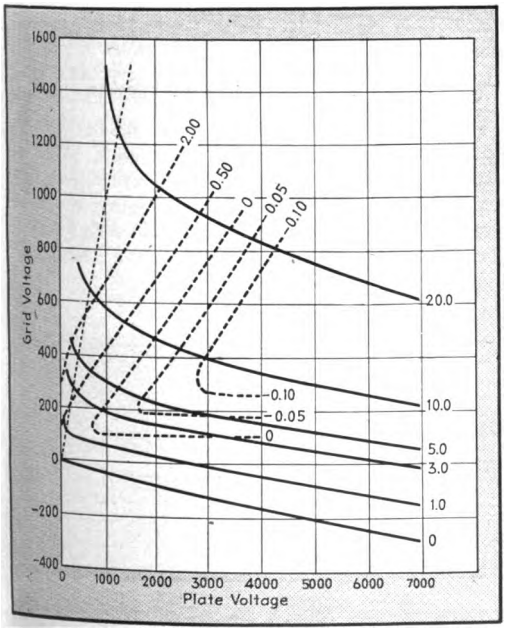

FIG. 13—Constant-current characteristics of α tube with α platinum grid. Solid-line curves represent plate current in amp; dashed-line curves represent grid current in amp

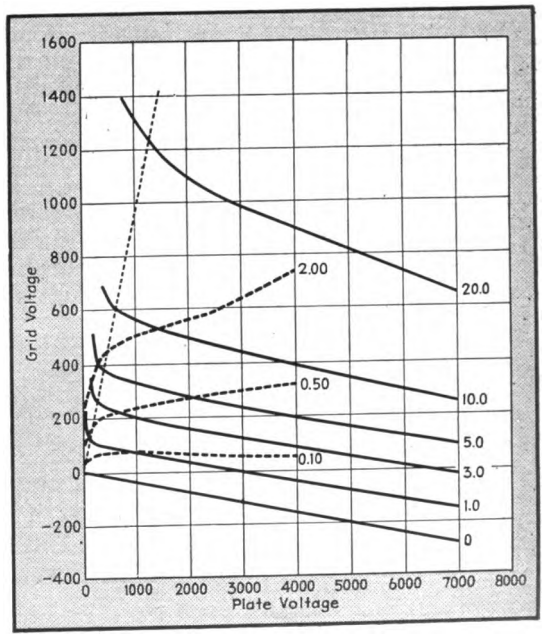

FIG. 14—Constant current characteristics of α tube with an X-grid. Solid-line curves represent plate current in amperes, while dashed-line curves represent grid current in amperes

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DUAL-TRIODE Trigger Circuits

Non-mathematical step-by-step description of the operation of the Eccles-Jordan trigger circuit, with practical suggestions for making the circuit distinguish between positive and negative pulses, and other helpful design data

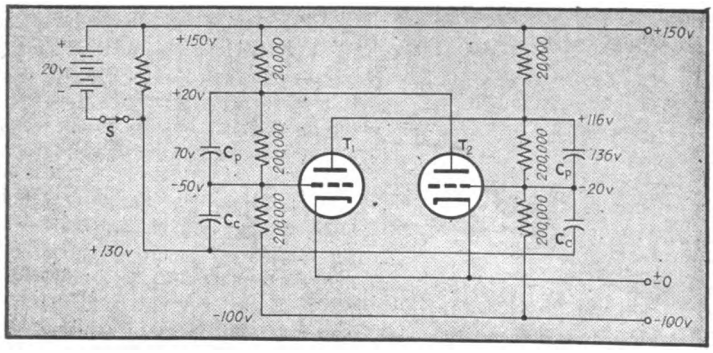

FIG. 1—The basic Eccles-Jordan trigger circuit

By BYRON E. PHELPS

International Business Machines Corp. Endicott, N. Y.

THIS PAPER is an attempt to give a graphical analysis of dual-triode trigger operation. It is hoped that it will clear up several points that apparently have not been too well understood, in particular the very vital function of the grid-to-plate capacitor (C_p in attached sketches) and the ability of the Eccles-Jordan type of triode trigger circuit to distinguish between positive and negative pulses if properly designed.

The dual-triode trigger described here is a device using two triode tubes so interconnected that one tube is normally conducting while the other is non-conducting. A suitable impulse applied at the proper points causes the first tube to become non-conducting and the other to conduct. A second impulse restores the original condition. This cycle may be repeated at will at any speed from zero up to speeds in the low radio-frequency range or even higher, depending on the circuit constants used.

The trigger may be used as a locking circuit, somewhat as a gaseous tube is used. Where it is so used, the circuit may be turned off as fast as it can be turned on, and very little energy is required to make it perform either function. Since two impulses are required to provide a complete trigger cycle, ie., to turn any one tube on and then off, the trigger can also be arranged to give one output impulse for every two input impulses and thus act as a frequency divider.

Basic Principle

Figure 1 shows the basic Eccles-Jordan trigger circuit. The two triodes T_1 and T_2 are so connected that the plate of each controls the grid of the other in such a manner that only one tube can conduct (on)

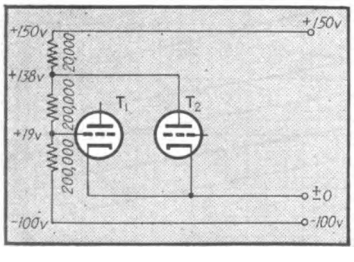

FIG. 2—Assuming that both tubes are initially non-conducting, application of voltage to the resistor network makes the grid of T_1 positive with respect to its cathode and this tube conducts

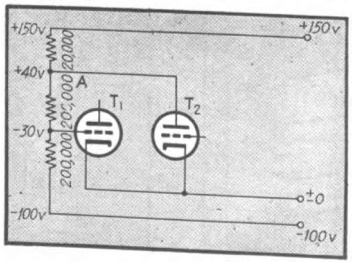

FIG. 3—When tube T_2 is conducting, tube T_1 is negatively biased and does not conduct. The plate of tube T_2 drops to +40 volts and point A is held at that potential during this part of the operating cycle

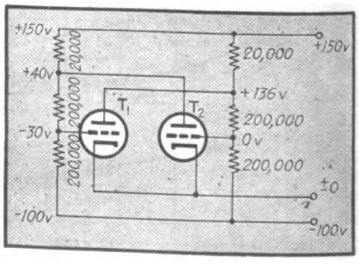

FIG. 4—The use of two resistor networks enables tube T_1 to control tube T_2 in a manner similar the way in which T_2 controls T_1 in Fig. 3. Voltages shown here are those applying when T_2 is conducting

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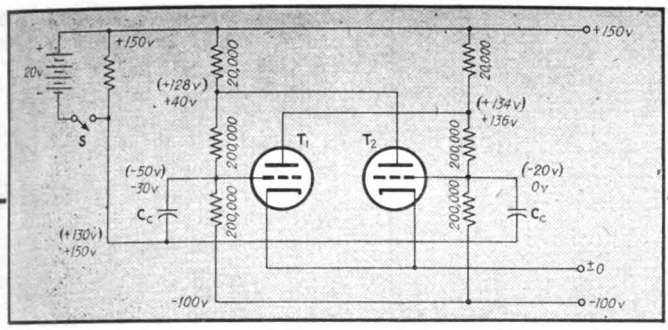

FIG. 5—Coupling capacitors C_c provide a means of temporarily biasing both grids together. This circuit is, however, incapable of reversing on the application of an impulse to both grids. Voltages indicated without parentheses are those applying with T_2 conducting but with switch S open. Voltages in parentheses are those applying at the instant switch S is closed

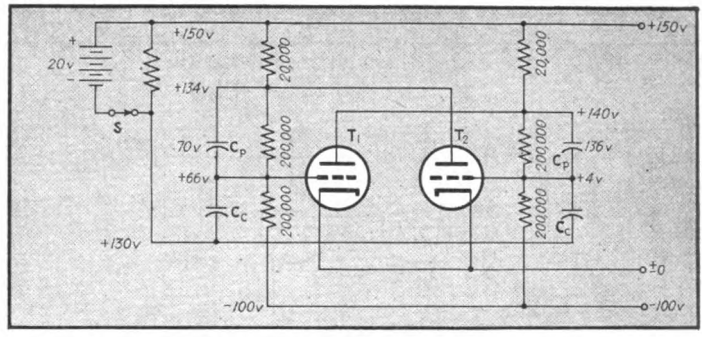

FIG. 7—Addition of capacitors C_p as shown here to the circuit of Fig. 5 makes possible the desired reversing trigger action. Voltages are those applying with T_2 conducting

at a time. The component values shown are merely illustrative and are used to simplify the analysis. However, these values will make a satisfactory trigger for relatively slow-speed operation.

The tubes used are 6J5's or equivalent and may be considered essentially as switches. When the grid of a 6J5 is at the same potential as its cathode the tube is conducting, just like a closed switch except that there is in the circuit illustrated a 40-volt drop between plate and cathode. When the grid is made negative with respect to its cathode by 8 volts or more, the tube is non-conducting and resembles an open switch in that no current can flow between plate and cathode.

Figure 2 shows more clearly how tube T_1 can control tube T_2. With both tubes arbitrarily rendered non-conducting, the voltage at the grid of T_1 is determined by the resistor network shown between the +150-volt line and the −100-volt line. By Kirchhoff's law, the grid of T_1 may be calculated to be 19-

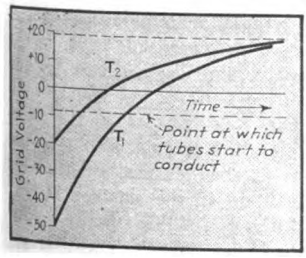

FIG. 6—Calculated grid-voltage rise after switch S of Fig. 5 is closed. Obviously, the grid of tube T_2 will be the first to reach the −8-volt line, so that T_2 turns on first when an initiating pulse arrives

volts positive with respect to its cathode, thus turning T_1 on. (Actually, sufficient grid current will normally flow in T_1 to hold its grid down to approximately cathode potential).

When tube T_1 is made conducting as shown in Fig. 3, its plate will drop to +40 volts and point A will be held at that potential. Again applying Kirchhoff's law, we find that the grid of T_2 is now 30-volts negative with respect to its cathode and that T_2 is thus held non-conducting by T_1. Connecting the grid of T_2 to the plate of T_1 with a similar network as shown in Fig. 4, will enable T_1 to control T_2 in the same manner, and we have the desired condition in which only one tube can be on at a time.

Circuit Details

Figure 5 shows a means of temporarily biasing-off both grids together through coupling capacitors C_c. Although this circuit has sometimes been shown as the basic Eccles-Jordan trigger circuit, it is fundamentally incapable of reversing on application of an impulse to both grids. The voltage values shown without parentheses are those existing with T_2 conducting and switch S open. Those in parentheses are the instantaneous values obtained when switch S is closed, delivering a 20-volt negative impulse to the grids through capacitors C_c. This 20-volt negative impulse will render both tubes non-conducting. Both grids will immediately start to rise to the resistance-network-limited value of +19 volts, the rate of rise being determined by the time constant of the resistor network and the C_c combination. Since these are the same for each tube, the time constant will be the same for both grids.

The rise of voltage on both grids will be as shown in Fig. 6. Obviously the grid of T_2 will be the first to reach the −8-volt line, which means that T_2 will be turned on first and will hold T_1 off as before. In other words, the trigger has not been reversed. Likewise, a positive pulse will not reverse the trigger since any effect it might have on the non-conducting tube will be

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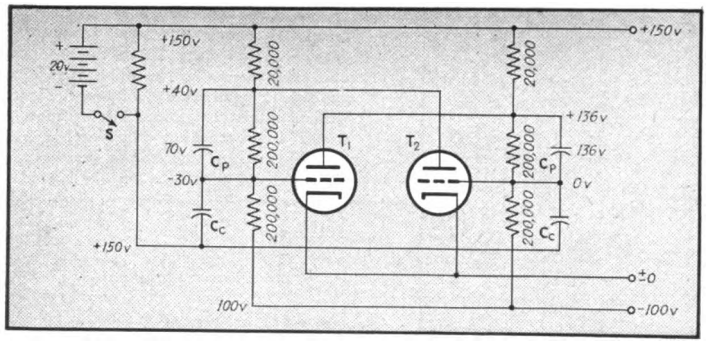

FIG. 8—A 20-volt negative impulse applied to the circuit of Fig. 7 by closing switch S, as shown here, drops instantaneous resistor-network potentials 20 volts

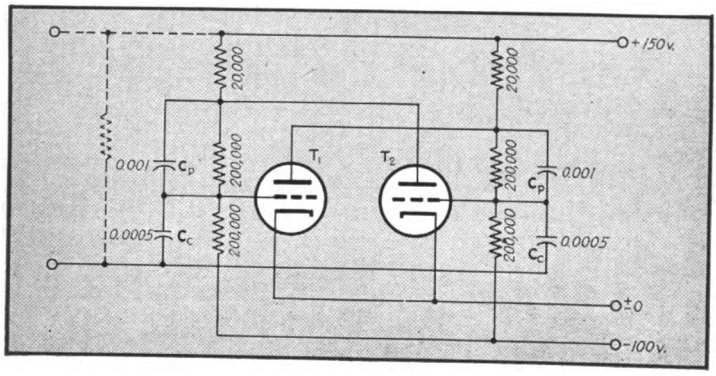

FIG. 9—If both tubes are held non-conducting by some external means, voltages shown in Fig. 8 will rise to these values soon after switch S is closed

offset by a stronger effect on the conducting tube.

It is the addition of the plate-to-grid capacitors C_p that makes possible the desired reversing trigger action. Figure 7 shows the addition of such capacitors to Fig. 5 and the steady-state voltages that exist with T_1 conducting. A 20-volt negative impulse provided by closing switch S will instantly drop all network voltages by 20 volts, as shown in Fig. 8. For simplification, assume that plate-to-grid capacitors C_p are so large in comparison to coupling capacitors C_c that there will be no change of voltage across them in the time required for the smaller coupling-capacitors to reach a steady-state condition. Assuming that the tubes are held non-conducting by some external means, the voltages in Fig. 8 will soon change to those in Fig. 9, with the coupling capacitors C_c in equilibrium. The rise of voltage of the grids will be as shown in Fig. 10.

While these curves might be accurately calculated, they were actually obtained by plotting an ε^{-x} curve between the known limits of grid voltage. Because of the much greater voltage-swing on T_1, caused by the relatively low voltage existing on the grid-to-plate coupling capacitor C_p between it and the plate of T_1, we see that the grid of T_1 (which has been non-conducting) is the first to reach the conducting point of -8 volts. Thus T_1 becomes conducting and blocks off T_2 and the trigger is reversed. The addition of the plate-to-grid capacitors C_p has produced the desired trigger action and the trigger will now reverse itself every time the grids are given a negative impulse.

In drawing Fig. 10, it was assumed that the grid-to-plate capacitors C_p were much larger than the grid capacitors C_c. That this assumption does not alter the general shape of the curves of grid voltage rise is best shown in Fig. 11, which is a sketch of the grid-voltage rise in an actual trigger circuit (as shown in Fig. 1 with $C_p = 2\ C_c$) as viewed on a large cathode-ray oscilloscope.

Originally tube T_1 is conducting and T_2 is held non-conducting by the -30-volt potential on its grid (voltage as shown in Fig. 7). At time T_0 a 20-volt negative impulse is applied to both grids through the coupling capacitors C_c. Due to internal impedance of the square-wave generator used in this instance, the negative impulse as it appears at the grids is not quite square and at the grids the peak negative dip is -15 volts. As soon as the maximum negative potential is reached, both grids start to rise in potential. As in Fig. 10, the grid of T_1 rises much faster than the grid of T_2 and reaches the conducting point first. When T_1 starts to conduct, its plate goes down, forcing the grid of T_2 way down and holding T_2 non-conducting. After an interval of less than 0.0001 sec., the charges on all capacitors have been equalized and the circuit is as before, except that T_1 is now conducting instead of T_2. The dotted lines indicate what the rise of the grid voltages might look like if the tubes could be held non-conducting by some external means.

Figure 12 shows both grid and plate-voltage changes for tube T_1 when the trigger (circuit as in Fig. 1) is triggered or reversed continually by a 3000-cycle square-wave input. (The grid-voltage curve is the same as those in Fig. 11.)

Positive and Negative Impulses

So far nothing has been said about the ability of this trigger circuit to distinguish between positive and negative impulses.

If a square-wave input is of a low enough frequency, the positive rise of the square wave will appear to the trigger grids as a positive impulse of a magnitude equal to the negative impulse produced by the negative shift of the square-wave signal. To act as a frequency divider, the trigger must respond only to the negative shift. This it will do if the impulse is kept within reasonable limits. For example, a 20-volt negative impulse will cut off the conducting tube, enabling the trigger to transfer; a 20-volt positive impulse will not bring the grid of the non-conducting tube up to the conducting

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point and thus cannot make the tube start to conduct. Its only action on the conducting tube is to drive the grid slightly positive. Therefore, the trigger will transfer only on a negative impulse or voltage shift and the trigger will act as a frequency divider on a 20-volt square-wave input.

The trigger circuit as shown will respond to negative pulses only, as long as they remain between the limits of 10 to 40 volts. Figure 12 shows why the trigger is not reversed on a positive pulse which is theoretically large enough to bring the grid of the non-conducting tube up to the conducting point. Notice that a point *B* the grid of the non-conducting tube actually appears to go negative although the square-wave input is shifting positively. This is because the positive impulse acting on the grid of the conducting tube drives its plate down almost 20 volts (point *C*). Through the plate-to-grid capacitor *C*, this dip of the plate of the conducting tube over-rides the positive impulse on the grid of the non-conducting tube, producing a negative dip as shown at *B*. (Although point *C*, as shown for tube T_1 is 180 deg. out of phase with point *B*, the corresponding point on the plate of T_2, if it were shown on Fig. 12, would be in phase with point *B*.

For a positive impulse to turn on the non-conducting tube, it must be large enough to overcome the initial bias plus the negative swing produced at the non-conducting tube's grid by the voltage dip of the conducting tube's plate. The dip in the conducting tube's plate voltage is in this case caused by the same positive impulse acting on its own grid. The input limits depend on the impedance of the input circuit. The figures of 10-40 volts were obtained with a battery serving as a very low impedance source. With a 20,000-ohm output impedance of the square-wave generator, the input may be varied from 10 to over 70 volts at 3000 cycles.

Coupling Several Triggers

All that is required to use a trigger circuit of the type described as a frequency divider is to hold the input signal to reasonable limits (25 volts ±15 volts for a low-impedance source). No extra tubes or pulse selectors are required.

To couple two triggers together, it is only necessary to tap one plate resistor of the first trigger at one-quarter to one-half its value, coupling to the input capacitors of the second trigger as shown in Fig. 13. Tapping the plate-load resistor at one-quarter to one-half its value serves to furnish a portion of the output of the first trigger within the required limits for operation of the second trigger. Thus we have a simple straightforward trigger circuit which is capable of distinguishing between positive and negative pulses without additional tubes. Such triggers when properly designed are stable, dependable, and independent of any reasonable voltage-supply variation (±20 percent variation in either bias or plate supply, more if both vary together).

As many triggers as desired may be coupled together by the methods outlined above to obtain any desired frequency reduction, the frequency being reduced by a factor of two for each trigger used. Such a frequency divider may be used in many ways, in combination with a mechanical counter for counting high-speed pulses far above the speed of the mechanical counter alone, in high-speed calculating, etc. A combination of a trigger and a power tube, where the trigger controls the power tube, may be used in place of a thyratron with the advantage that it may be turned off as easily as it is turned on. The triggers alone or in combination may also be used as electronic storage devices, since they are perfectly stable in either position.

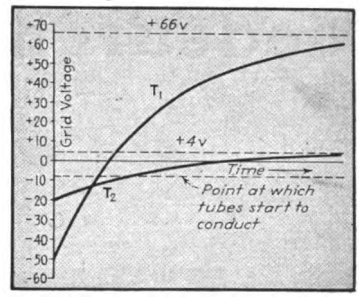

FIG. 10—Calculated grid-voltage rise as circuit voltages change from those shown in Fig. 8 to those shown in Fig. 9

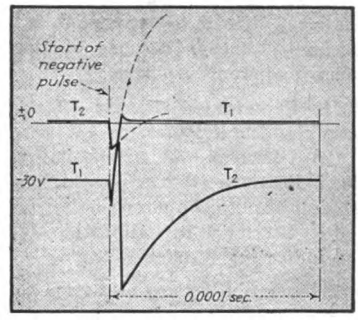

FIG. 11—Actual grid-voltage rise in the circuit of Fig. 1, as viewed on a cathode-ray oscilloscope

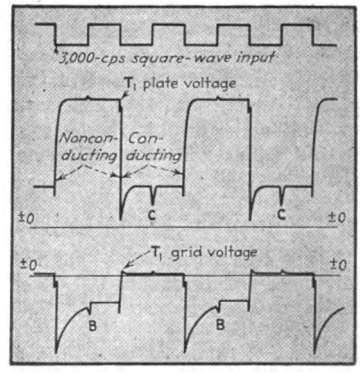

FIG. 12—Overall trigger circuit operation, as sketched from a cathode-ray oscilloscope

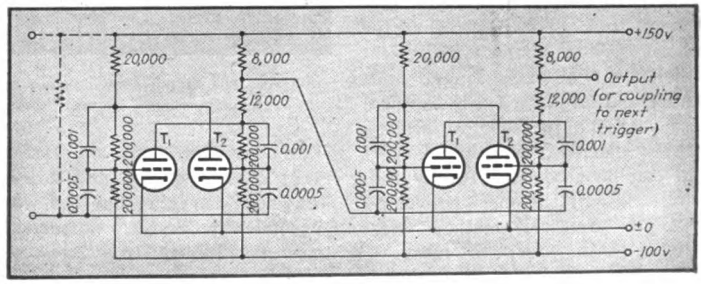

FIG. 13—Method of coupling two or more dual-triode trigger circuits

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Measurement of STRESSES in

Resistance-wire strain gages mounted on the shaft facilitate vibration analysis and fatigue-strength calculations. Methods of measuring both steady and alternating stresses caused by thrust, bending and torque are discussed. Tests on the propeller shafts of naval vessels are used as examples

By W. F. CURTIS
David Taylor Model Basin
Navy Department
Washington, D. C.

MEASUREMENT of alternating stresses in rapidly moving mechanical parts has long been desirable for vibration analysis and fatigue-strength calculations. This has been difficult to accomplish by mechanical means because of the following major problems:

(1) Presence of inertia effects in mechanical linkages.

(2) Difficulty of transmitting the indications from a rotating or moving part to the observer.

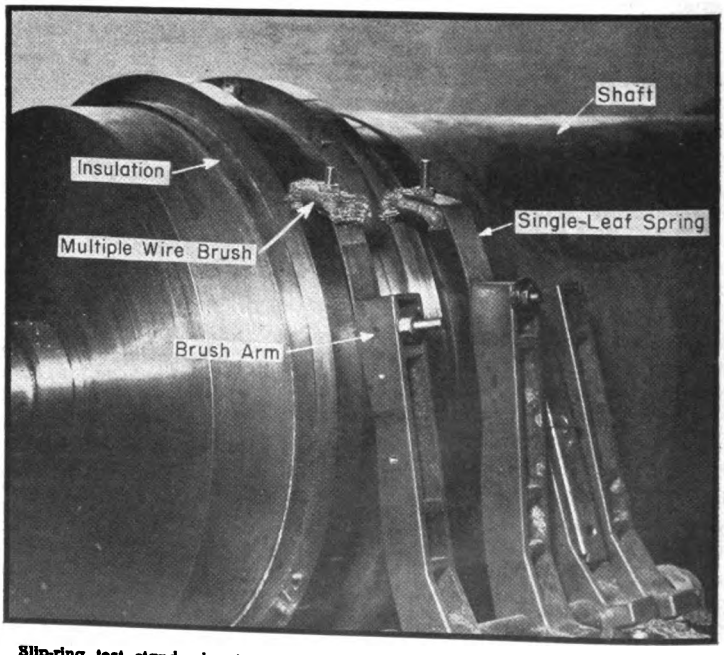
(3) Difficulty in calibration of the indicating mechanism.

These problems are all easier to solve when electrical or electronic methods of measurement are employed. There are a number of such methods by which stress can be measured. Of these, the method which utilizes resistance-wire strain gages has been developed farthest and has been used in the widest variety of rotating-shaft applications. For this reason, the present paper will be confined to this method.

Resistance-Wire Strain Gages

It has long been known that the resistance of granulated carbon can be changed by pressure. Following this lead, carbon strips have been used as strain gages, but while the resistance of such strips changes markedly with stress, the behavior of carbon-strip gages is quite erratic.

The same effect exists in metals, although to a lesser degree than in carbon. When a metal wire is stretched, it becomes longer and thinner and its electrical resistance increases; the increase in resistance is usually somewhat larger than can be accounted for by the change in dimensions. Development of practical methods for utilizing this effect to measure stress and strain started about 1938, E. C. Simmons[1] and associates at California Institute of Technology and Ruge and DeForest at Massachusetts Institute of Technology carrying out the work independently and apparently almost simultaneously.



Slip-ring test stand, showing ring and brush construction recently adopted for measurement of stresses where the end of the shaft is not accessible

Strain gages employing this principle were soon made commercially available by the Baldwin-Southwark division of the Baldwin Locomotive Works. These gages have been used extensively for vibration measurements and strength testing. Dohrenwend's paper[2] is typical of much of such work.

The active element in these

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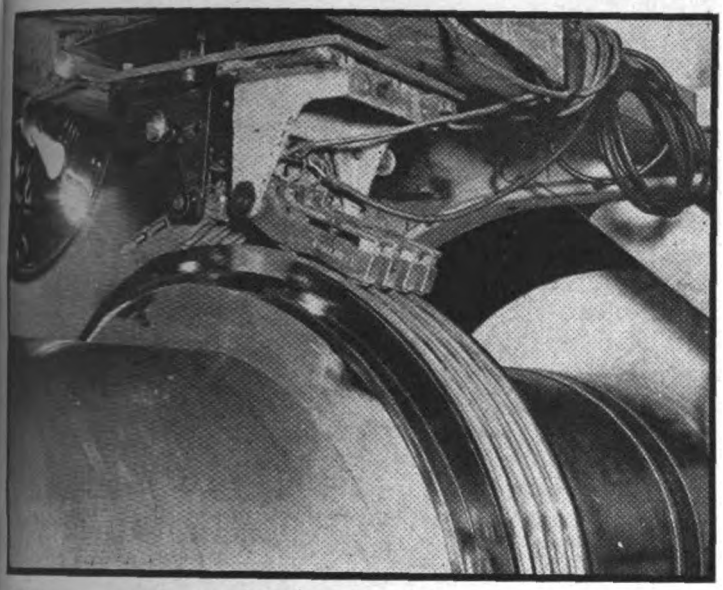
in ROTATING SHAFTS



Early slip-ring installation on the propeller shaft of a naval vessel. Four carbon brushes were used on each ring

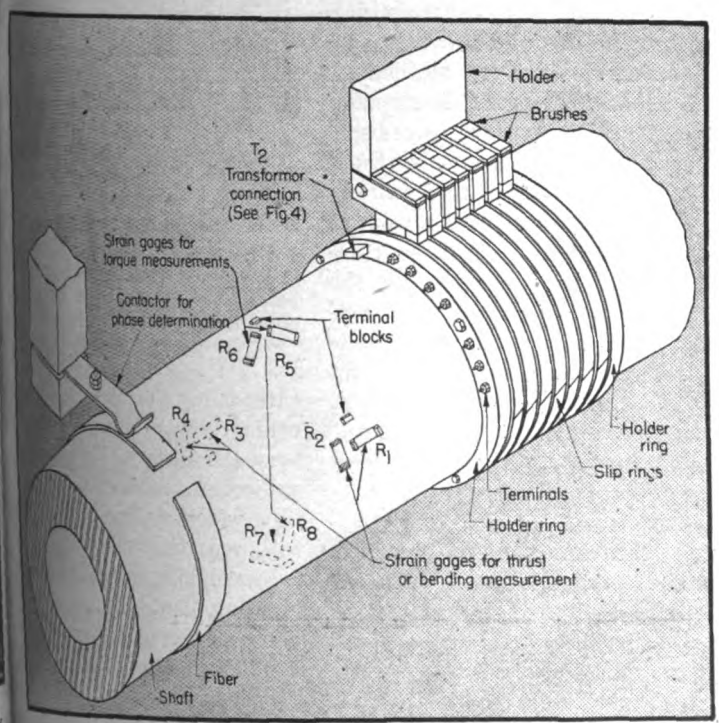


FIG. 1—Schematic of measuring apparatus mounted on a shaft

gages is a metal wire about 0.001 inch in diameter, laid in multiple-loop form and conveniently mounted on paper for cementing to the part under test. The diameter of the wire must be of this order to assure adequate bonding to the test piece. An important property of the gage is that it undergoes a change in resistance proportional to the strain in the wire and hence to the strain in the member under test, or

$$\Delta R/R = k\Delta l/l$$

This equation is valid for both tension and compression if the wire is adequately bonded to the test piece so as to prevent buckling. Exact values of k are supplied by the manufacturer for each lot of gages; $k \cong 2$ for gages of Advance wire having a low temperature coefficient and generally used for measurement of steady strains. For gages of isoelastic wire, $k \cong 3.5$; these gages have a higher temperature coefficient than the Advance wire gages but are very satisfactory for measuring alternating strains.

Locating Gages on Shaft

Figure 1 shows the location of gages on a shaft for measuring the three principal stresses: thrust, bending, and torque. It will be noted that from two to four gages are used in each circuit. The chief purpose of this multiplicity of gages is to discriminate among the different types of stress, but the arrangement also results in a reduction in temperature errors, a reduction in the electrical disturbances caused by the sliding brushes, and an increase in sensitivity.

Gages R_1 and R_3 are mounted with their strain-sensitive axes parallel to the axis of the shaft; the axes of gages R_2 and R_4 are perpendicular to the shaft axis. If the shaft is subjected to an axial compression, such as the propeller thrust produces in the propeller shaft of a ship steaming ahead, gage R_1 is subjected to a compressive strain and gage R_3 is subjected to a compressive strain of equal magnitude. Because of the Poisson effect, gages R_2 and R_4 experience a tensile strain a third to a fourth as great as the compressive strain in gages R_1 and R_3.

Any rotating shaft will be subjected to an alternating bending stress, due to its own weight, and to other bending stresses due to any misalignment and unbalance which may exist. These forces are usually small in themselv

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their effect on the shaft may be magnified by resonance effects to a degree which endangers the shaft or its bearings. If at any instant gage R_1 is subjected to a compressive stress due to bending, gage R_4 is also subjected to a compression and gages R_2 and R_3 are subjected to a tension. Furthermore, the magnitude of the compressive stress in R_1 is equal to the magnitude of the tensile stress in R_3, and R_2 and R_4 are similarly affected.

If a shaft is subjected to torsion, the principal strains in the surface are directed at an angle of 45 degrees to the shaft axis, the strains being compressive for one set of 45-degree lines and tensile for the set which is at right angles to the direction of the compressive stress. Thrust and bending forces produce no strains along these 45-degree lines. Gages can be readily located along these lines by using a paper template wrapped around the shaft.

These facts can be used to devise circuits in which resistance changes due to the desired type of stress have an additive effect on the output and changes due to the undesired type balance out. Cancellation of the undesired effect is complete if the orientation of the gages is exact and if $R_1 = R_3$ and $R_2 = R_4$. The circuits of Fig. 2 and 3 are arranged to accomplish this cancellation.

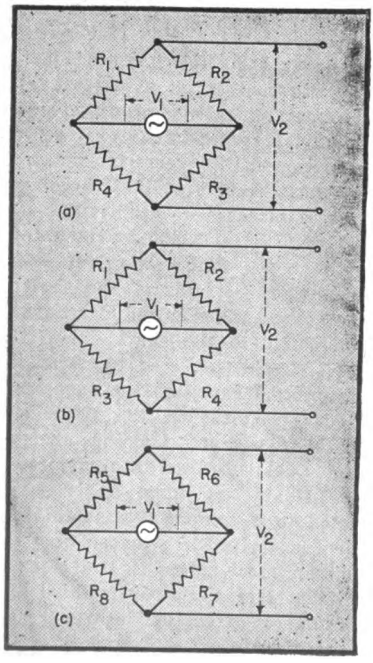

FIG. 2—Basic bridge circuits for measuring steady and alternating stresses. Resistors are the strain gages shown in Fig. 1. The arrangement at (a) is used for thrust measurements, that shown at (b) is employed for bending measurements, and (c) is for torque measurements

Choice of Circuit

Several types of measuring circuits are available. The choice of circuit depends, first of all, on the frequency characteristics of the stresses being investigated. Wherever steady stresses are to be measured, a bridge type of circuit is indicated. For measuring steady stresses only, on land installations, a d-c bridge supply is used and a sensitive galvanometer is employed as an indicator. Such galvanometers are useless on shipboard, so that some other method must be used if shipboard experiments or the measurement of vibratory quantities is contemplated.

A d-c bridge-supply could conceivably be used with d-c amplification, but the use of a-c bridge-supply and carrier-current methods is much to be preferred. Some additional complications are introduced by the use of carrier, notably those due to the necessity of maintaining the bridge in reactive as well as resistive balance, but these complications are outweighed by the fact that the carrier-current amplifier is superior to the d-c amplifier in reliability, freedom from hum, gain, stability and simplicity. Carrier-current methods are well adapted to simultaneous measurement of both steady and alternating stresses.

If alternating stresses only are to be measured, the circuits of Fig. 3 are indicated. This makes it possible to dispense with the carrier-current source (usually a 5-watt electronic oscillator) and the bridge control equipment. In addition, the inconvenience of maintaining the balance of a bridge is avoided, and the potentiometer supply-battery can often be mounted on the shaft, thus minimizing much of the difficulties experienced with brush contacts.

Obtaining stress records by photographing the screens of

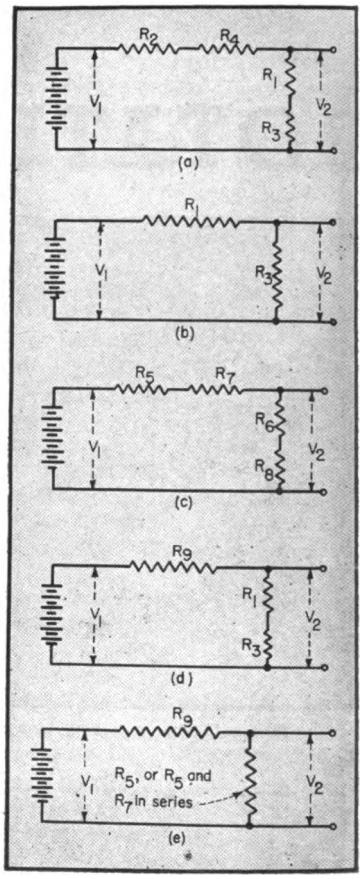

FIG. 3—Basic potentiometer circuits for measuring alternating stresses only. Resistors R_1 to R_4 are strain gages, while R_5 is a fixed resistor generally mounted on the rotating shaft but not shown in Fig. 1. Circuit (a) is for thrust measurements, (b) for bending, (c) for torque, (d) for simplified thrust measurements, and (e) for simplified torque measurements

cathode-ray oscilloscopes in the ordinary way is possible but not very satisfactory. The stresses are subject to random variations in time which confuse a record taken with repeating sweep and are apt to cause misconceptions if single sweep is used. Due to the short length of record, harmonic content is difficult to determine from cathode-ray pictures; furthermore many vibration investigations require taking four to 12 simultaneous records. This can be done conveniently with a magnetic oscillograph but not so conveniently with cathode-ray oscilloscopes.

Choice of Recording Instrument

Several commercially available oscillographs are supplied with

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galvanometers that have an undamped natural frequency of about 2000 cps and will therefore reliably record frequencies up to 600 or 700 cps, which is ample for unrectified carrier recording and more than ample for rectified carrier or direct recording of vibration stresses in machine parts. These galvanometers require about 5 ma per inch deflection and hence can be driven direct-coupled from low-power receiving tubes such as the 6J5. A further increase in sensitivity would offer little advantage and would involve a galvanometer sensitive to mechanical shock and inferior in frequency range.

Unrectified Carrier Method

The unrectified carrier method of measurement is the simplest method by which both steady and alternating stresses can be measured. Gages are mounted in accordance with Fig. 1 and connected in accordance with Fig. 2. The choice of carrier frequency is dictated by a typical engineering compromise. A high carrier frequency permits the measurement of higher-frequency stress oscillations but requires a somewhat more critical reactance balance. Carrier frequencies in the neighborhood of 400 cps have been found satisfactory for most shipboard applications, although frequencies as high as 1500 cps have been used.

The principal circuit arrangements are shown in Fig. 4. All long connections are made with shielded microphone cable; by following this practice it has been found possible to locate the measuring instruments as much as 200 feet from the shaft without deleterious effects. This fact is often useful on shipboard, where instrument locations near the propelling machinery are often undesirable for one reason or another. Transformer T_2, shown as located on the shaft, can be located at the amplifier input without great loss in signal-to-noise ratio. Capacitors C_1 and C_2 are used for balancing out stray capacitances.

In practice, switches S_1 and S_2 and resistor R_0 are adjusted so that a value of decade shunt resistor S between 20,000 and 50,000 ohms will balance the bridge when the shaft is idle. Adjustment of the bridge to balance when the shaft is idle—that is, stressed as little as possible—is known as the zero balance adjustment.

Suppose the bridge is adjusted to zero balance and the shaft then subjected to its normal load. If, as is normally the case, the stress being measured has a steady component and an alternating component whose peak value is less than the steady component, the bridge output will be a modulated sine wave whose percentage modulation is less than 100. The distance between the upper and lower envelopes at any point of an oscillogram of this modulated wave is proportional to the instantaneous stress in the shaft.

Figure 5 is a sample oscillogram taken by the unrectified carrier method. Changing the setting of shunt S (Fig. 4) will change the amplitude of the unmodulated portion of the bridge output by a constant amount. So far as the bridge output is concerned, this is equivalent to adding or subtracting a constant stress, the magnitude of the addition being calculable by formulas presented later in this paper. If the alternating component of stress is a small fraction of the steady component, this feature can be used to increase the portion of the record taken up by the alternations. If the alternating component of the stress is greater than the steady component, this feature can be used to prevent overmodulation. The bridge must always be adjusted so that the bridge output never falls to zero, otherwise the interpretation of the oscillogram is uncertain.

Figure 6 shows the circuit of an amplifier suitable for both the unrectified and rectified-carrier methods of measurement.

Rectified Carrier Method

Two advantages result from rectifying the bridge output before applying it to the oscillograph; the oscillograph is not required to record such high frequencies, and the resulting oscillogram is easier to read.

Simple diode rectification of the output is easily accomplished but is not too satisfactory. The bridge must in any case be adjusted so that its output is not overmodulated and yet the steady component of carrier frequency must not be large enough to saturate the amplifier. The presence of an unsuitable amount of carrier is not very obvious on the oscillograph when the carrier is simply rectified.

It is much better to use a bridge-detector circuit which registers the direction as well as the amplitude of the bridge unbalance. Many balanced detectors are phase-sensitive. A particularly simple and successful circuit is the one given in Fig. 7, which is similar in some respects to the circuit of the cosine galvanometer manufactured by the Hickock Instrument Company.

In practice, R_1 is adjusted so that the output milliammeter reads zero

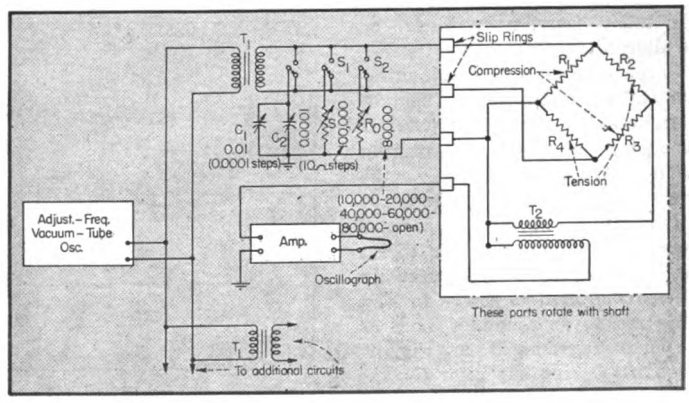

FIG. 4—Circuit used for unrectified carrier method of measurement. T_1 is an isolating transformer which also matches bridge input impedance to oscillator output impedance. T_2 is a step-up transformer bridge output to single grid, chosen for low 60-cycle hum pickup

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when the input terminals of the carrier-current amplifier are shorted. Then, if the bridge is unbalanced in a direction such that the grids of VT_1 and VT_2 are positive when the plate of VT_1 is positive, the plate current of VT_1 is increased. This requires that the grids be negative when the plate of VT_2 is positive, so that the plate current of VT_2 is decreased. As the current through the galvanometer

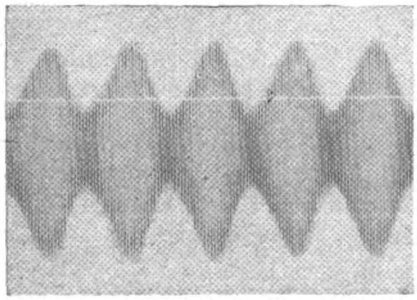

FIG. 5—Sample oscillogram obtained by the unrectified-carrier method

and output meter is the difference of these two currents, the net result is an average rectified current in the direction given by the arrow. An unbalance in the opposite direction results in output current in the opposite direction. The bridge can therefore be kept balanced for the average existing stress at all times, the oscillograph recording the instantaneous departures from average and the milliammeter serving as a null indicator for the steady component.

A sample oscillogram taken by the rectified carrier method is given in Fig. 8.

Direct Method

In many cases, a knowledge of the alternating component of stress is all that is desired; in fact, vibration testing is the major field of usefulness of the technique for measuring stresses in rotating shafts. Where measuring the steady component is unnecessary or impractical, labor and apparatus are conserved by using the direct method. The output of the strain gages (connected as shown in Fig. 3) is fed to an amplifier such as the one diagrammed in Fig. 9, through blocking capacitor C_1.

The principal difficulty involved is that the extremely low frequencies encountered complicate [illegible] design. Alternating stresses whose frequencies are as low as 2 cps are often encountered; frequencies above 30 cps are rare. For these low frequencies, transformer coupling is out of the question. The oscillograph galvanometer, which has an impedance of 12 ohms or less, must be direct - coupled to the output stage. The other stages are resistance-capacitance coupled and their design presents no particular difficulties except drift. That is, the output voltage of a very low-frequency amplifier is likely to vary spontaneously over a considerable range, the period of the variations being rather indeterminate but of the order of several seconds.

Mr. George Cook of the David Taylor Model Basin staff points out that drift is largely due to small variations in the amplifier supply voltages and particularly to the difficulty in maintaining the potentials of the screen grids of the early stages rigidly constant over so long a period. For this reason, the plate supply is derived from a carefully designed electronic regulator. Type 12SJ7 amplifier tubes are used, and their heaters (in series) are supplied with direct current from the regulator. As screen bypass capacitors adequate down to a fraction of a cycle are impractical, screen potentials are supplied from a dry battery. Although the current required is only 0.1 ma per tube, the smaller-size B batteries were found unsatisfactory due to high internal resistance, so that medium-size B batteries had to be used.

When this development was started, it was anticipated that connections to and from the g mounted on the rotating s would represent the most diffi of the problems to be solved. W this expectation proved to be rect, it has been found possibl make slip rings and brushes wl are quite satisfactory.

Slip-Rings and Brushes

A ray of hope was offered at outset by A. C. Ruge, who poi out that if a complete bridg mounted on the shaft and the br connections inserted in the in and output leads of the bridge, iations in brush resistance prod only second-order effects on output. Nevertheless, the seco order effects are sufficiently trou some so that good brush cont are required in any case.

Analysis of the circuits invol shows that the total variation in contact resistance of the brus carrying the input current is principal disturbing factor. T necessity for using the adjusta shunt resistor off the shaft (S Fig. 4) makes the problem m worse than it otherwise would Brush contacts also generate sm random voltages or brush ha when the rings are rotating. T voltages thus arising from the sl ing contacts in the bridge or tentiometer output circuit are jectionable if present, but in ge eral cause less trouble than va ing resistance in the input cc tacts.

The requirements for brush for this purpose are, then, gre

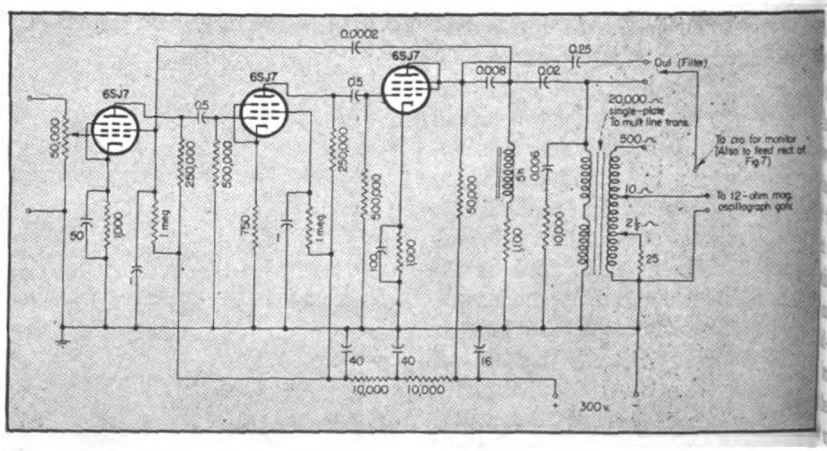

FIG. 6—Circuit of amplifier used with both unrectified carrier-current method and rectified carrier-current method. The filter is adjusted to give maximum flatness between 800 and 1,200 cps and maximum attenuation below 180 cps for minimizing hum. When using the amplifier in conjunction with the rectifier of Fig. 7 the filter is omitted to avoid possible phase shift

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constancy of contact resistance and low-amplitude brush hash. At the low current levels used, the contact does not show the nearly constant drop-of-potential characteristic of motor and generator brushes. The brush has a fairly definite average contact resistance. As the disturbing factor is the total resistance change rather than the percentage change in contact resistance, low average contact resistance is a desirable feature. In general, brush hash is likely to be tolerable if the materials of brush and ring are not too dissimilar. It will be seen that the requirements for a good brush for this application are quite different from the requirements for a motor or generator brush in conventional applications.

It is obvious that any tendency for the brush to leave the ring even momentarily produces intolerable interference; nevertheless the paramount importance of proper alignment of the rings was not appreciated for some time. In many cases, as for example when measuring stresses in the propeller shafts of ships, the ends of the shaft are not accessible so that it is necessary to make the rings in halves and clamp them around the shaft. It has been found that filling the crack between the ring halves with solder and dressing down with a file reduces brush interference by a large factor. Polishing the rings with a commutator-dressing stone while they are rotating has also proved helpful.

A number of different combinations of ring and brush material have been tried. Present practice is as follows: A standard connector unit comprising 12 silver rings with silver-graphite brushes has been constructed. The construction of this unit is shown in Fig. 10 and 11. This provides enough contacts for almost any test and is used whenever the end of the shaft being tested is accessible. For installation where the end of the shaft is not accessible, half-rings are formed from square brass stock and clamped around the shaft, as shown in a photograph appearing on the first page of this paper. A multiple-wire brush is now always used. The optimum brush-pressure is the least pressure which will hold the brush on the ring.

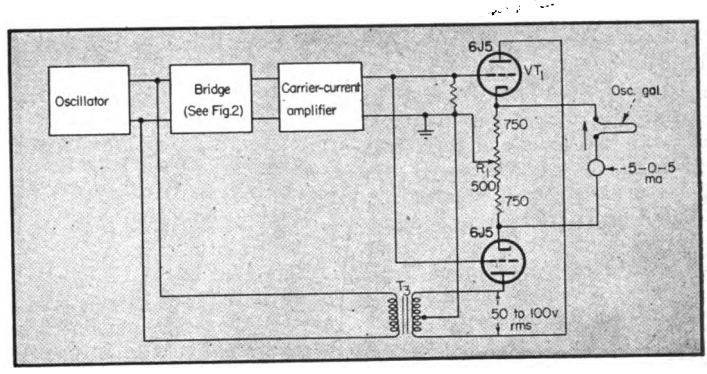

FIG. 7—Circuit used for the rectified-carrier method of measurement

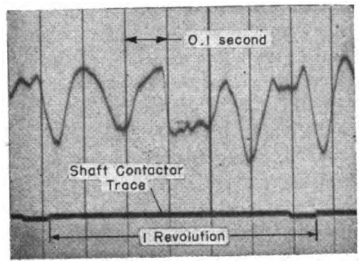

FIG. 8—Sample oscillogram obtained by the rectified-carrier method

Computation of Results

Let

A = cross-sectional area of shaft, sq. in.,
D = outside diameter of shaft, in.
d = inside diameter of shaft, in.
E = Young's modulus of shaft, lb. per sq. in.;
G = shear modulus of shaft, lb. per sq. in.;
N = Poisson's ratio of shaft
Q = torque applied to shaft, lb.-in.
T = axial thrust applied to shaft, lb.
M = bending moment at gage location, lb.-in.
S_v = shearing stress in shaft due to torque, lb. per sq. in.
S_T = axial stress in shaft due to thrust, lb. per sq. in.
S_B = fibre stress at gage location due to bending, lb. per sq. in.
R_1 to R_8 = unstressed resistances of gages of Fig. 1, ohms
R_9 = resistance of ballast resistor, Fig. 4.
δ = specific resistance variation of gage
v_1 = instantaneous value of input to strain-gage bridge or potentiometer, volts (v_1 is constant for potentiometer)
V_1 = input to strain-gage bridge, rms volts
v_2 = instantaneous value of output from bridge or potentiometer, volts
V_2 = output from bridge or potentiometer, rms volts

When the shaft is subjected to an axial compression (thrust) T, gages R_1 and R_2 (Fig. 1) are subjected to a strain along their strain-sensitive axes of magnitude T/AE. As a compressive strain produces a decrease in resistance, the resulting specific change in resistance is

$$\delta_T = -kT/AE$$

Due to the Poisson's effect, gages R_2 and R_4 are subjected to a strain of magnitude NT/AE in tension. This produces an increase in specific resistance

$$\delta_T' = NkT/AE = N\delta_T$$

Similarly, a bending moment M, if applied to the shaft in the proper orientation, produces a specific resistance change

$$\delta_B = \frac{k S_B}{E} = \frac{32\,k\,M\,D}{\pi E\,(D^4 - d^4)}$$

in gage R_1, a specific resistance change of $-N\delta_B$ in gage R_2, etc.

Torsion in the shaft subjects R_1 to R_4 to a shear strain only, and hence does not affect their resistances. Similarly, thrust and bending do not affect the resistances of gages R_5 to R_8. Torsion produces a strain

$$\frac{\Delta l'}{l'} = \frac{S_v}{E}(1 + N)$$

in gages R_5 and R_7 and a strain

$$\frac{\Delta l''}{l''} = \frac{-S_v}{E}(1 + N)$$

in gages R_6 and R_8. As $E = 2G(1 + N)$ and $Q = (\pi/16)[(D^4 - d^4)/D]S_v$, the corresponding specific resistance change is

$$\frac{\Delta l''}{l''} = -S_v(1 + N)$$

$$\delta_Q = \frac{k\,\Delta l'}{l'} = \frac{8\,k\,Q\,G\,D}{\pi\,(D^4 - d^4)}$$

The resistances of the gages under stress are then respectively

$R_1(1 + \delta_T - \delta_B)$
$R_2(1 - N\delta_T - N\delta_B)$
$R_3(1 + \delta_T + \delta_B)$
$R_4(1 - N\delta_T + N\delta_B)$
$R_5(1 + \delta_Q)$
$R_6(1 - \delta_Q)$
$R_7(1 + \delta_Q)$
$R_8(1 - \delta_Q)$

where the δ's have all been defined in terms of the unknown forces or moments and shaft geometry.

It is now only necessary to determine the δ's in terms of the re-

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sistor values used and the output voltages found during the experiments. This can readily be done by setting up the Kirchhoff law equations for the circuits of Fig. 2 and 3, using the resistances of the gages under stresses as just given. These computations are straightforward but rather lengthy and will not be reproduced here.

Taking advantage of the facts that (a) all the δ's are very much less than unity (of the order of 0.001 or less); (b) the shunt resistor S can be kept very much larger than any of the gage resistances; and that (c) the value of the auxiliary shunt resistor does not affect the result if it is kept constant during the tests, the results can be expressed by the following simple formulas:

If any one of the bridges shown in Fig. 2 is balanced when the shaft is substantially unstressed, and if when the shaft is subjected to a load the bridge output is V_2, then

For measurement of thrust

$$\delta_T = \frac{2}{1+N}\left(\frac{V_2}{V_1}\right)$$

$$S_T = \frac{2E}{(1+N)k}\left(\frac{V_2}{V_1}\right)$$

$$T = \frac{2AE}{(1+N)k}\left(\frac{V_2}{V_1}\right)$$

For measurement of bending

$$\delta_B = \frac{2}{1+N}\left(\frac{V_2}{V_1}\right)$$

$$S_B = \frac{2E}{(1+N)k}\left(\frac{V_2}{V_1}\right)$$

$$M = \frac{\pi E\,(D^4 - d^4)}{16\,(1+N)\,kD}\left(\frac{V_2}{V_1}\right)$$

For measurement of torque

$$\delta_Q = \frac{V_2}{V_1}$$

$$S_T = \frac{2G}{k}\left(\frac{V_2}{V_1}\right)$$

$$Q = \frac{\pi G\,(D^4 - d^4)}{8\,k\,D}\left(\frac{V_2}{V_1}\right)$$

Note that $V_1/V_2 = v_1/v_2$. The phase-shift in the carrier produced by the bridge and amplifier reactances results only in a time delay which is constant for all frequencies of stress variation if the phase-distortion in the amplifier has been kept low, and is of negligibly small magnitude if the carrier frequency is larger than the frequencies of stress variation by a sufficiently large factor. For this reason, either instantaneous or rms voltage values can be used in the preceding set of equations, and also in the two sets of equations immediately following. These equations can be readily extended to cover cases where the bridge is not maintained at zero balance. If S_o is the value of the shunt resistor S which results in zero output when the shaft is not stressed, then the values of the typical specific resistance, stress, and force or moment of force which will result in zero output with some other value of shunt resistance S' are given. For measurement of thrust, the specific resistance change for obtaining balance with shunt S'

$$\bar{\delta}_T = \frac{R_4\,(S_o - S')}{2\,(1+N)\,S_o\,\delta'}$$

The stress for balance with shunt S'

$$\bar{S}_T = \frac{E}{k}\,\bar{\delta}_T'$$

The thrust for balance with shunt S'

$$\bar{T} = \frac{AE}{k}\,\bar{\delta}_T$$

For measurement of bending

$$\bar{\delta}_B = \frac{R_4\,(S_o - S')}{2\,(1+N)\,S_o\,S'}$$

$$\bar{S}_B = \frac{E}{k}\,\bar{\delta}_B$$

$$\bar{M} = \frac{\pi E\,(D^4 - d^4)}{32\,k\,D}\,\bar{\delta}_B$$

For measurement of torque

$$\bar{\delta}_Q = \frac{R_4\,(S_o - S')}{4\,S_o\,S'}$$

$$\bar{S}_T = \frac{2G}{k}\,\bar{\delta}_Q$$

$$\bar{Q} = \frac{\pi G\,(D^4 - d^4)}{8\,k\,D}\,\bar{\delta}_Q$$

The resistance of the auxiliary shunt R_s does not matter as long as it is the same for all values of S. Furthermore, if the bridge output is V_2 when the shunt resistance is S', then the total specific resistance changes δ_T, δ_B and δ_Q, the total changes in stress S_T, S_B and S_T and the total changes in force or moment T, M and Q are given by thrust

$$\delta_T = \bar{\delta}_T + \frac{2}{1+N}\left(\frac{V_2}{V_1}\right)$$

$$S_T = \bar{S}_T + \frac{2E}{(1+N)\,k}\left(\frac{V_2}{V_1}\right)$$

$$T = \bar{T} + \frac{2\,AE}{(1+N)\,k}\left(\frac{V_2}{V_1}\right)$$

bending

$$\delta_B = \bar{\delta}_B + \frac{2}{1+N}\left(\frac{V_2}{V_1}\right)$$

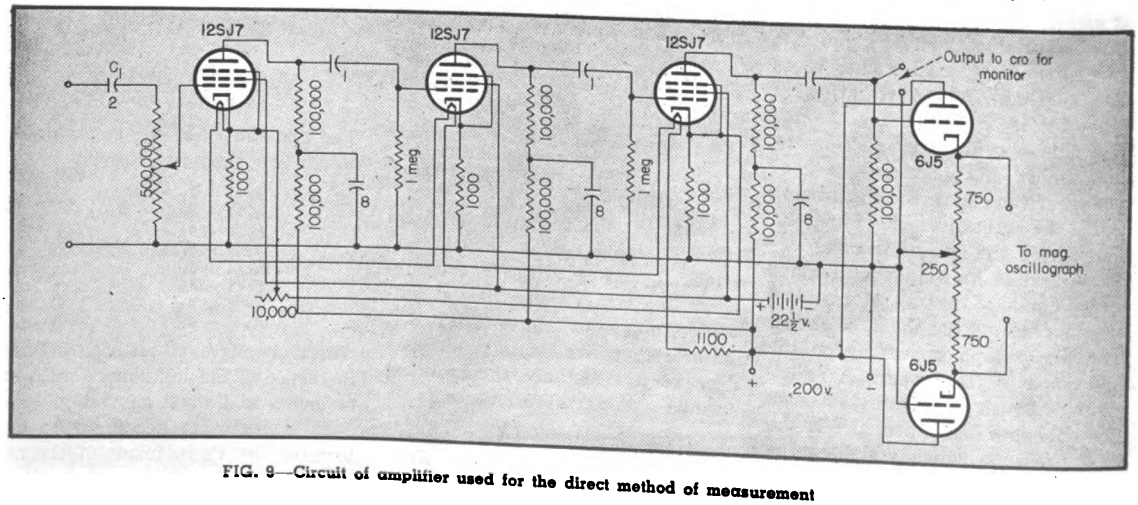

FIG. 8—Circuit of amplifier used for the direct method of measurement

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$$S_s = \overline{S}_s + \frac{2E}{(1+N)\,k}\left(\frac{V_2}{V_1}\right)$$

$$M = \overline{M} + \frac{\pi E (D^4 - d^4)}{16(1+N)\,k\,D}\left(\frac{V_2}{V_1}\right)$$

torque

$$\delta_Q = \overline{\delta}_Q + \frac{V_2}{V_1}$$

$$S_T = \overline{S}_T + \frac{2G}{k}\left(\frac{V_2}{V_1}\right)$$

$$Q = \overline{Q} + \frac{\pi G (D^4 - d^4)}{8\,k\,D}\left(\frac{V_2}{V_1}\right)$$

The circuits given in Fig. 3 are always used with capacitance coupled amplifiers, so that the oscillograph indicates only the alternating component of output voltage. For this reason, it is best to express the results thus obtained in terms of departures from average values of resistance, stress, and force, rather than in terms of departure from the condition of no external load as was done for the bridge circuits. With this understanding, the formulas for interpreting the results of measurements by the direct method are as follows:

for circuit of Fig. 3(a)

$$\delta_T = \frac{4}{1+N}\left(\frac{V_2}{V_1}\right)$$

for circuit of Fig. 3(d)

$$\delta_T = \frac{(R_1 + R_3 + R_9)^2}{(R + R_3)\,R_9}\left(\frac{V_2}{V_1}\right)$$

for circuit of Fig. 3(b)

$$\delta_S = 2\,\frac{V_2}{V_1}$$

for circuit of Fig. 3(c)

$$\delta_Q = 2\,\frac{V_2}{V_1}$$

for circuit of Fig. 3(e)

$$\delta_Q = \frac{(R_6 + R_7 + R_9)^2}{(R_6 + R_7)\,R_9}\left(\frac{V_2}{V_1}\right) \text{ or } \frac{(R_6 + R_9)^2}{R_6\,R_9}\left(\frac{V_2}{V_1}\right)$$

Calibration of Equipment

In cases where the shaft studied may be stopped at will, the two carrier-current methods lend themselves to very simple and accurate calibration in terms of the shunt resistor S, which should be a precision decade resistance box.

Let y be the peak-to-peak carrier amplitude as measured on the oscillogram in an unrectified carrier system, or the deflection of the trace in an oscillogram taken by the rectified carrier system. If then y_1 is the observed amplitude or deflection taken when the shunt

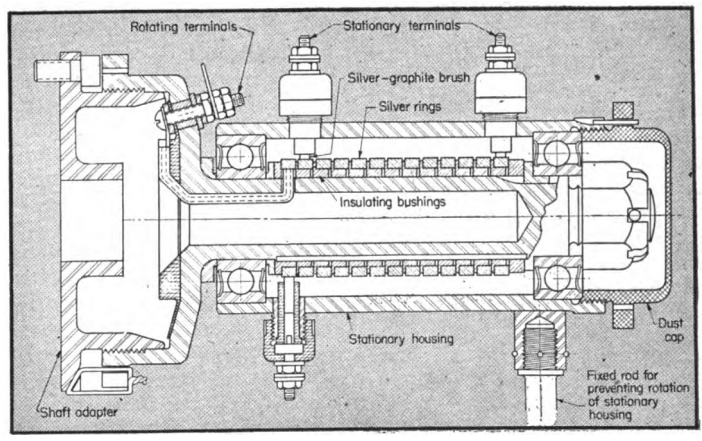

FIG. 10—Drawing of connector unit employed whenever the end of the shaft under test is accessible, an adaptation of a design furnished by the Hamilton-Standard Propeller Company. The unit is pictured in Fig. 11

resistance is $S_1 < S_0$ and y_2 is the observed amplitude or deflection taken when the shunt resistance is $S_2 > S_0$ (where S_0 is the shunt resistance for zero balance), then it can be shown from formulas already presented that

for circuit of Fig. 2(a)

$$T = \frac{A\,E}{2\,k\,(1+N)}\;\frac{R_1(S_2 - S_1)}{S_1 S_2}\;\frac{y}{(y_1 + y_2)}$$

for circuit of Fig. 2(b)

$$M = \frac{\pi E (D^4 - d^4)}{64\,k\,(1+N)\,D}\;\frac{R_1(S_2 - S_1)}{S_1 S_2}\;\frac{y}{(y_1 + y_2)}$$

for circuit of Fig. 2(c)

$$Q = \frac{\pi G (D^4 - d^4)}{32\,k\,(D)}\;\frac{R_5(S_2 - S_1)}{S_1 S_2}\;\frac{y}{(y_1 + y_2)}$$

where y is the instantaneous deflection or amplitude on an oscillo-

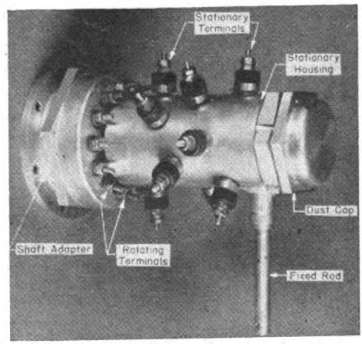

FIG. 11—The connector unit shown schematically in Fig. 10

gram taken with any desired load on the shaft, and T, M, Q are corresponding instantaneous values of thrust, bending moment, and torque respectively.

Unfortunately some shafts, as for example the propeller shafts of ships, cannot be stopped at will. Calibrations of this type can be made with the shaft under load by using averages values of y_1 and y_2, but if the average stress varies in the interval between the recording of the first and second oscillograms, errors will be introduced.

Potentiometer-type strain-gage circuits can be calibrated by momentarily shunting the gages in one arm of the potentiometer with a known high resistance. As the associated recording equipment is not capable of registering d-c potentials, this results in a transient excursion of the oscillograph beam; the deflection corresponding to the resistance change can be estimated but is subject to some uncertainty. The experience of the author with this method of calibrating potentiometer-type gage circuits indicates that the accuracy is rather low. Change of shunt resistance, however, is the most accurate method of calibrating strain-gage bridges if the stresses in the shaft can be maintained constant during the calibration.

Alternatively, calibration can be accomplished by measuring the voltage sensitivity of the amplifier-oscillograph combination and the voltage supplied to the gage circuit. It must be remembered, however, that while the deflection of the oscillograph beam is proportional to instantaneous voltage, most a-c voltmeters and standard signal-generators are calibrated in rms volts.

The voltage sensitivity of the

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amplifier-oscillograph combination is

$$K_e = \frac{2.828\ V_e}{y_e}$$

(instantaneous) volts per inch where y_e is the peak-to-peak deflection produced by an input signal of V_e rms volts, when using the unrectified carrier or direct method and y_e is the deflection (from zero) produced by an input of V_e rms volts when using the rectified carrier method. Then for thrust measurements by either of the carrier-current methods

$$T = \overline{T} + \frac{2AE}{(1+N)k}\ \frac{K_e y}{(2.828\ V_1)}$$

$$= \overline{T} + \frac{2AE}{(1+N)k}\ \frac{V_e}{V_1}\ \frac{y}{y_e}$$

where T is total instantaneous thrust, $\overline{T}$ is the steady thrust for which the bridge is balanced, y is the distance between the upper and lower envelopes at any point of the oscillogram if unrectified carrier is used, and y is the distance from the zero line to the trace if rectified carrier is used.

For thrust measurements by the direct method, instantaneous values of the alternating component of thrust are given

for the circuit of Fig. 3(b)

$$T = \frac{4AE}{(1+N)k}\ \frac{K_e y}{v_1} = \frac{11.31\ AEV_e}{(1+N)\ kv_1}\ \frac{y}{y_e}$$

for the circuit of Fig. 3(c)

$$T = \frac{AE}{k}\ \frac{(R_1 + R_3 + R_9)^2\ K_e y}{(R_1 + R_3)\ R_9\ v_1}$$

Similar formulas for bending and torque measurements can be written readily enough.

Accuracy and Sensitivity

The accuracy of measurements made with resistance-wire strain-gages is affected by many factors in a complex way. No completely definitive analysis of the errors involved has yet been made so far as the author is aware. Nevertheless, the upper limit of the probable over-all error is quite definitely known and it can be confidently stated that the accuracy and sensitivity are sufficient for most engineering tests.

If four strain-gages are cemented to a nonrotating part and connected into a bridge-type network, it will be found that the zero balance of the bridge drifts rather erratically as time goes on, even under laboratory conditions. The reason for this is not entirely understood. In general, temperature effects are the principal source of errors in measuring steady stresses. The gage-wire itself has a low temperature coefficient of resistance, but in general the material to which the gage is cemented has a coefficient of expansion different from that of the wire, and the resulting differential expansion produces strains in the wire which in turn produce resistance changes. Furthermore, it is possible that there may be small changes in the gage constant k as the temperature changes. However, in laboratory experiments of the type just described, observed temperature changes did not correlate very well with the drift in zero balance.

Another source of difficulty is the leakage resistances associated with the bridge. This effect is especially severe when measurements must be made in a damp location such as the shaft alley of a ship. Radiant heaters have occasionally been installed in the hope of preventing condensation of moisture on the slip-ring insulators by raising the temperature slightly. The effect of leakage resistance increases with the square of the gage resistance; however, reducing the effective gage resistance by using two or three gages in parallel in each arm of the bridge did not appreciably improve the over-all accuracy.

Still another probable source of error is plastic flow in the cement used to secure the gages to the parts under test. The accuracy which has been obtained in tests, where it was possible to check the results of the gage measurements, indicate that the gage wire must follow the strains in the surface to which it is attached quite closely. However, the precise magnitude of effects of flexibility in the cement is still somewhat in doubt.

In some cases, it has been possible to check the values of the steady component of stress in shafts by means of independent measurements. In these cases, the stress values obtained from the strain-gage measurements were rarely in error by more than 100 pounds per square inch; this result agrees with early estimates published by the Baldwin-South wark Company. This error is quit tolerable if the stress being mea ured is at all high. In cases whe temperature changes do not occ rapidly and zero balance can b checked frequently, it should b possible to improve this figure co siderably.

It has not been possible to ob tain such definite checks on the a ternating components of stress i shafts. It is estimated that the a curacy of measurement is about 1 per cent in cases where severe ten perature changes are involved, an three to five per cent under mo favorable circumstances.

The sensitivity to stress chang depends on whether or not th change occurs rapidly enough to b distinguishable from the drift i zero balance. When the stre change occurs at a frequency o 2 cps or more, the sensitivity d pends only upon the ability to di tinguish stress changes from inte fering stray potentials arisin from the amplifier and particular from the brush contacts. Such di ferentiation can often be made o the basis of wave-form or fr quency.

Under good conditions, alterna ing stresses as low as 10 pound per square inch have been detecte It will thus be seen that the sens tivity of the method is ample fo engineering tests.

Acknowledgments

The author desires to express hi indebtedness to the following mem bers and former members of th David Taylor Model Basin staff:

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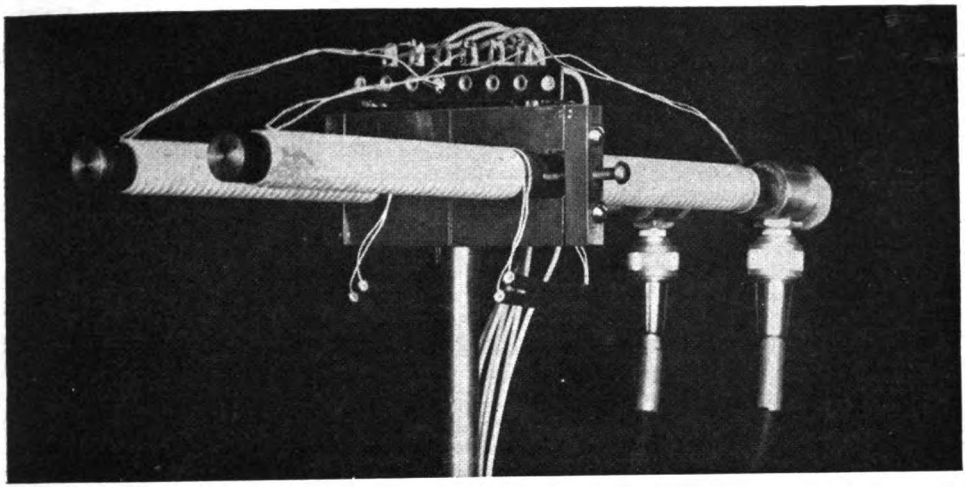

Experimental model of magnetostriction compass, employing a balanced two-rod arrangement. Systems employing a single rod are equally feasible

MAGNETOSTRICTION COMPASS

Rods of magnetostrictive material are subjected to an a-c magnetic field, and rotation in the earth's field changes the amplitude of vibration sufficiently to actuate a crystal pickup feeding an electronic amplifier and zero-center direction-indicating meter

By R. G. ROWE
Niagara Falls, New York

WHILE THE GYRO COMPASS and radio range systems have aided immeasurably in the art of avigation, the magnetic compass still persists as a tremendously useful and important device. All magnetic compasses, however, suffer several definite impediments to accurate operation, one of which is known as the acceleration error. For example, with a magnetic compass mounted in aircraft, for a right turn from a north course the compass will indicate that the pilot is turning left, due to the fact that during the banked turn the plane of the pendulously mounted compass card tilts from horizontal and rotates erroneously owing to the now-present vertical component of the earth's field. On a left turn the reverse action will take place, rendering this type of compass inaccurate as a turn indicator.

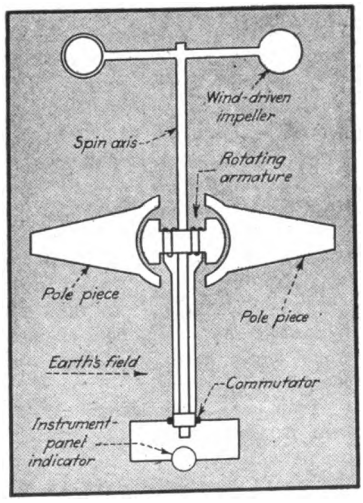

FIG. 1—Elementary magneto compass, in which the field for the rotating armature is provided by the magnetic field of the earth passing through the highly permeable pole pieces

A further compass error is often introduced through the unfavorable magnetic location of the compass on the instrument panel of the aircraft, because of the proximity of the motor and the disturbing fields of wires carrying current to other instruments and controls.

Magneto Compass

The magneto compass provided one of the first means for eliminating errors due to unfavorable magnetic location of the field-responsive device as well as substantially reducing errors due to acceleration. In Fig. 1 is an elementary sketch of the magneto compass, which consists of a coil rotating between the specially shaped

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pole pieces consisting of two highly permeable rods. When the rod axes lie in an east-west direction no poles are induced and no voltage is generated by coil rotation. When the rod axes are in a north-south direction poles are induced and a voltage is generated. By pendulous or gyro stabilization of the rods, acceleration error may be reduced. The rod axes may tilt over a restricted range with respect to the armature spin axes without affecting compass operation. This field-responsive device may be installed in a variety of favorable magnetic locations, with appropriate leads to the indicating meter on the instrument panel.

In the magneto type of compass there are limits to the reduction of the acceleration error, partially due to the mechanical limits of the tilt between the rod axis and the armature spin axis. Further, this compass requires some sort of motor drive for the armature as well as commutation to rectify the developed voltage. It would be an advantage to eliminate the rotating armature and provide some other means for indicating flux density in the permeable rod. In recent years this has been accomplished effectively by using rods or thin sheets of a material which is partially or fully saturated by the earth's magnetic field. Electrical means are provided for indicating the state of saturation of the material according to its position in the earth's field, generally employing various modifications of a transformer with the easily saturable material as the core.

Magnetostriction Phenomenon

The experimental magnetic field-responsive device or compass described here, which may be called a magnetostriction compass, does not depend on core saturation for its operation. Instead, this compass employs the effect of weak fields, such as the earth's field, on the magnetostrictive action of various materials exposed to the observed field.

In general, magnetostriction refers to that set of phenomena in which certain materials exhibit a change in dimension upon magnetization. Figure 2 graphically illustrates the way in which various

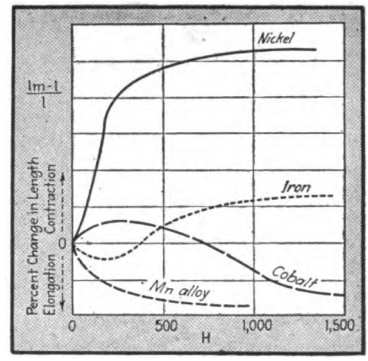

FIG. 2—Examples of magnetostriction curves for various materials, showing the percent change in length with intensity of a magnetic field H

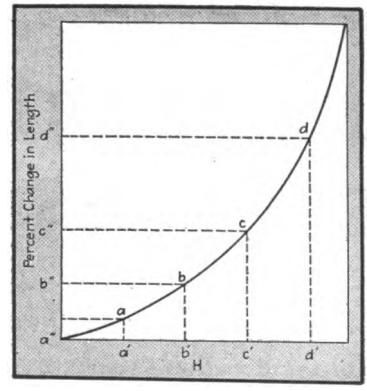

FIG. 3—Expanded magnetostriction curve, illustrating how shifting of the operating point causes changes in amplitude of vibrations produced by a superimposed a-c field

ferromagnetic substances change their length in a magnetic field.

If a rod of ferromagnetic or magnetostrictive material is suspended in the field of the earth, the length of the rod changes in accordance with its position in the field. The change in length attending magnetization by weak fields such as that of the earth is so exceedingly minute, however, that rugged mechanical means for indicating the dimensional changes would be difficult to design and construct.

When an alternating current field is impressed on a partially premagnetized rod in addition to the steady field under observation, however, variations in the intensity of the observed field will cause a remarkable change in the resonant amplitude of vibration of the rod. This action can be readily explained with reference to the expanded magnetostriction curve in Fig. 3.

When the rod is so positioned that the earth's magnetic field places the operating point at b on the curve, an a-c field that swings H from a' to c' about operating point b will make the change in rod length vary between a'' and c''. If the rod is then moved more nearly parallel to the earth's magnetic field so as to shift the operating point to c on the curve, the same a-c field will now cause a much greater change in rod length, from b'' to d''.

When the frequency of the applied alternating magnetic field is closely matched to that of a natural elastic longitudinal period of the rod, resonance occurs between the electrical and mechanical systems and the amplitude of rod displacement becomes large enough to be detected electrically by conventional vibration pickups. Steady magnetic fields of low intensity, such as the earth's field of 0.15 to 0.30 gauss, are of sufficient magnitude to shift the operating point on the curve and produce variations in the amplitude of vibration of the rod.

Magnetostriction Compass

An experimental version of the magnetostriction compass is shown schematically in Fig. 4. Magnetostriction rods A and B are made of annealed steel and cut to identical dimensions so both will resonate at the same frequency. A close approximation of the fundamental longitudinal period of the rods may be determined by

$$f = \frac{1}{2l}\sqrt{\frac{E}{d}}$$

where f is frequency in cps, l is rod length in cm, E is the elastic modulus of the rod material in dynes per sq cm, and d is the density of the rod material in grams per cu cm. For a rod of annealed steel 25.4 cm long for which d is 7.8 and E is 22 x 10^{11}, the resonant frequency is approximately 10,000 cps.

Both of the rods in Fig. 4 are firmly clamped at their midpoints (nodes), permitting the assembly to be rotated in the horizontal component of the earth's field while the rods are retained parallel and in the same plane. To facilitate mount-

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ing, the coils on each rod are split into two sections. The alternating-current winding is close-wound directly on each rod, with the premagnetizing winding space-wound directly over it. The a-c windings are excited from a convenient source of alternating current such as an audio signal generator. The battery, potentiometers, and premagnetizing windings cooperate to magnetize each rod oppositely and independently.

To detect the longitudinal rod vibration, a shielded piezoelectric rochelle salt crystal is affixed at the end of each rod. The remainder of the circuit is quite conventional, with two audio amplifiers to amplify the rod output signals, two tuned filter circuits to pass only the rod frequency, and a balanced metering circuit to indicate changes in amplifier output which are caused by changes in rod output.

Operation of Compass

Initially, rods *A* and *B* are positioned in an east-west direction and slightly but oppositely magnetized by the battery, potentiometers and premagnetizing windings. An alternating excitation voltage is then applied to the other windings by a variable-frequency generator, the frequency of which is tuned to the mechanically resonant fundamental longitudinal period of the rods. Rod resonance is easily observed by noting amplifier output. When the approximate fundamental period is first determined by calculation, slight frequency adjustment over the neighboring range will assure resonance between the electrical and mechanical systems. The gain of the amplifiers and the setting of the potentiometer in the metering circuit are now adjusted so that the center-zero meter shows no deflection.

Now when the rods are rotated, magnetic flux lines appear along the longitudinal axes of the rods due to the earth's magnetic field. If the polarity of this new field adds to the premagnetized condition of rod *A*, it will simultaneously buck the premagnetized condition of rod *B*, because the two rods are oppositely premagnetized. The vibrational amplitude of rod *A* will increase and that of rod *B* will decrease, unbalancing the balanced metering circuit and causing the meter to deflect to the right, for example. For opposite polarity of this new field, the meter will deflect in the opposite direction. When the longitudinal axes of rods *A* and *B* are parallel to the horizontal component of the earth's field, the zero-center meter will give a maximum deflection either to right or left, according to the field polarity.

Other Applications

Another promising circuit utilizes one premagnetized magnetostriction rod as a magneto-mechanical feedback link in a regenerative system equipped with volume compression, where the plate current of the compressor tube indicates the direction or magnitude of the observed field. Other circuits measure the phase angle between the exciting and output voltages of the rod as modified by the external field.

An unmagnetized nickel rod becomes shorter when introduced into a magnetic field, the change in length depending on field intensity but not field polarity. In an alternating field the rod will be shortened twice for each complete cycle of the exciting voltage. A steady field may shift the operating point, varying the percentage of second harmonic component in the fundamental vibration, and this waveform distortion is easily detectable.

The discovery that magnetic fields of low intensity exert an electronically measurable influence upon mechanically resonant magnetostrictive systems, as well as the initial development of suitable electronic measuring means, points out the way for further development in the field of magnetics. To the physicist it provides an approach to plotting magnetostrictive curves at low field intensities. To the metallurgist it offers the possibility of developing magnetostrictive materials with particularly suitable and novel magnetic properties. To the electronic engineer it affords the basis for new concepts and improvements in instrumentation.

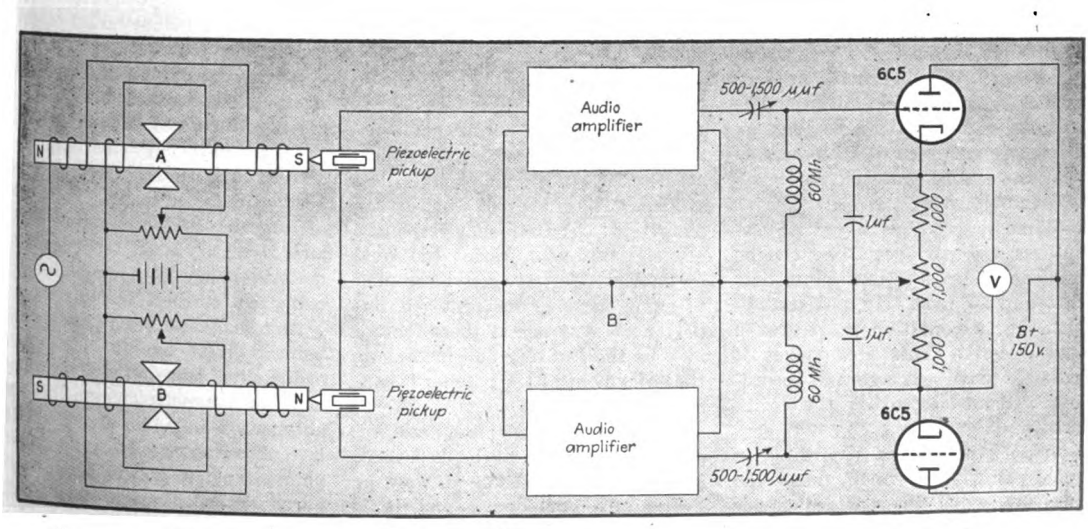

FIG. 4—One form of magnetostriction compass circuit, employing two vibrating rods in a balanced arrangement, with zero-center voltmeter *V* calibrated to indicate direction

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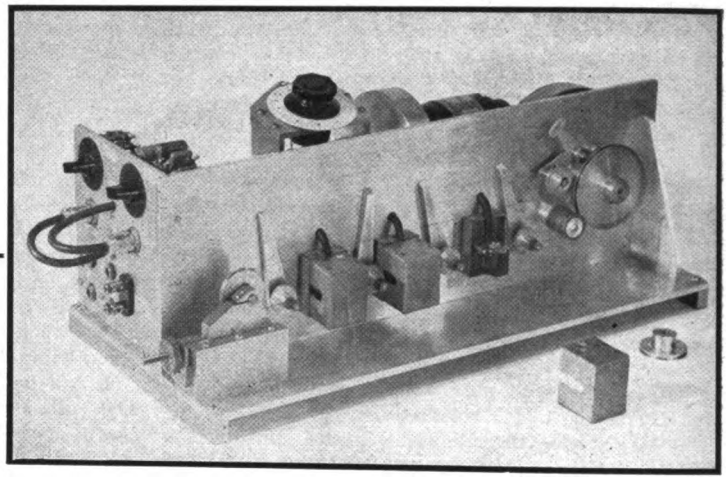
Supersonic Bias for



Front view of loop tester, showing the shielded recording, erasing, and reproducing heads. To the extreme right is the driving capstan. The calibrated dial for speed control is above and to the back; this dial reads wire speed in fps

By
LYNN C. HOLMES
and
DONALD L. CLARK
Research Department
Stromberg-Carlson Company
Rochester, N. Y.

Research indicates the optimum value of a supersonic bias field for improving linearity of magnetic transfer characteristics and reducing magnetic noise level. Measurements indicate the effects of recording-reproducing head design and wire speed on frequency response

RECENT DEVELOPMENTS in magnetic recording have created a new and widespread interest in this recording method. Using magnetic recording it is easily possible to produce records of any desired length. It is possible to record a complete symphony or, in the case of speech recordings, an entire book on a single length of wire without any splice. Another great advantage in the use of magnetic recording, as compared with recording on discs, is that the record material shows no appreciable wear.

When a record has served its usefulness, the wire recording can be erased by exposure to a supersonic field and the recording medium will then be in condition to receive a new record. This also makes it possible to correct errors in recording without destroying the entire record.

As the novelty of recording on magnetic wire wears off, those who are interested in recorded music from the viewpoint of the fidelity of the recording rather than the novelty of the method are going to compare this newer method critically with some of the older methods. If magnetic recording is not equal to, or better than the older methods which are now used for the recording of music, it will soon lose favor with these critical listeners except for novel entertainment.

Recording Characteristics

There are four major performance characteristics to be considered in the study of any recording system. These are: (a) non-linear distortion; (b) frequency response; (c) signal-to-noise ratio; (d) wow or flutter. We have not attempted to name these in the order of importance. Any one of these factors may be the limiting one insofar as the enjoyment of the listener is concerned.

We shall consider magnetic recording in relation to the first three in detail. The effects of wow or flutter are well-known and it is sufficient for the purpose of this paper to point out that wows which are not even noticeable with speech may be intolerable with music. In general, it is also true that all the requirements for good reproduction of music are much more severe than those for the intelligible reproduction of speech.

In any practical magnetic recording system, some method of biasing is necessary in order to place the operating range on a linear portion of the transfer characteristic. The most obvious method and the one used in early systems employed direct current in the recording head. Investigation of the effects of superimposed alternating fields and direct fields on ferromagnetic materials showed the possibility of using a supersonic field for bias.

Any magnetic recording system using direct-current bias will ordinarily leave the recording medium magnetized even in the absence of an audio signal. This is a disadvantage from the viewpoint of noise, as will become apparent later. On the other hand, the system using a supersonic bias leaves the recording medium practically demagnetized except when an

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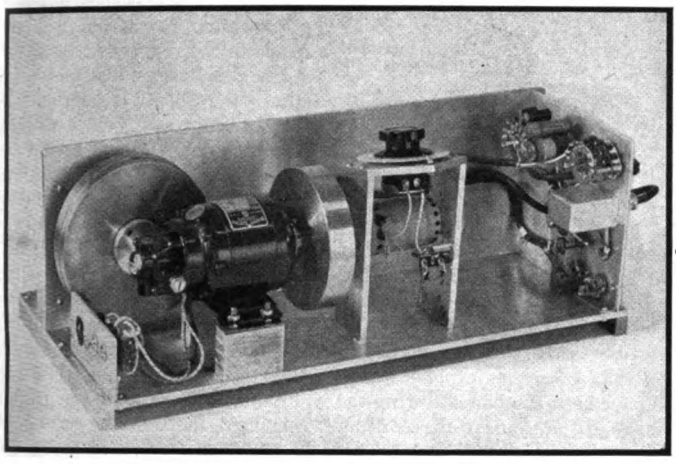
Magnetic Recording



Back view of loop tester. Flywheels for reducing speed fluctuations are attached to the high and low-speed shafts of the driving motor. An alternator connected to the high-speed shaft actuates the electronic speed control

audio signal is being recorded. This is an inherent advantage and should result in a higher signal-to-noise ratio than is obtainable with earlier systems.

Laboratory Apparatus

A block diagram of a complete magnetic recording system employing a supersonic bias field is shown in Fig. 1. The recording medium used for the work described in this paper was in the form of round wire; longitudinal magnetization was employed. For laboratory work the system was made as flexible as possible. Two well-shielded, recording-reproducing heads and an erasing head are used, making it possible to record and then play back a fraction of a second later. The auxiliary equipment includes amplifiers with flexible equalizers for recording and reproducing, oscillators with adjustable output and frequency for biasing and erasing, and an electronic speed control for the reversible-drive motor. Frequency-response measurements are made with an automatic frequency-response recorder.

Photographs of a loop tester for making tests with a short, endless loop of wire are shown. With this apparatus it is possible to test experimental recording, reproducing, and erasing heads, as well as samples of recording wire. Frequency response measurements, signal-to-noise ratio measurements and even listening tests can be made, as well as various other tests.

Magnetic recording is possible because certain ferromagnetic materials retain some magnetic induction after removal of an applied magnetic field. The portion which is retained is called remanence. For the benefit of those readers who may not be familiar with the distinction between remanence and residual induction in magnetic terminology the following definitions are given. *Remanence* is the magnetic induction which remains in a magnetic circuit after the removal of an applied magnetomotive force. *Residual induction* in a magnetic material is the magnetic induction at which the magnetizing force is zero when the material is in a symmetrically cyclicly magnetized condition. Remanence is usually less than residual induction because of the self-demagnetizing field.

Magnetic Materials

The relation betwen the residual induction and the field intensity by which it is produced is not linear. A graph showing the normal magnetization curve and the residual induction curve for a sample of carbon-steel wire is shown in Fig. 2. Starting with a completely demagnetized recording medium, it can be seen that severe distortion will occur unless some means of biasing is used. A field alternating at a supersonic frequency can be used to provide this bias.

We shall now analyze the com-

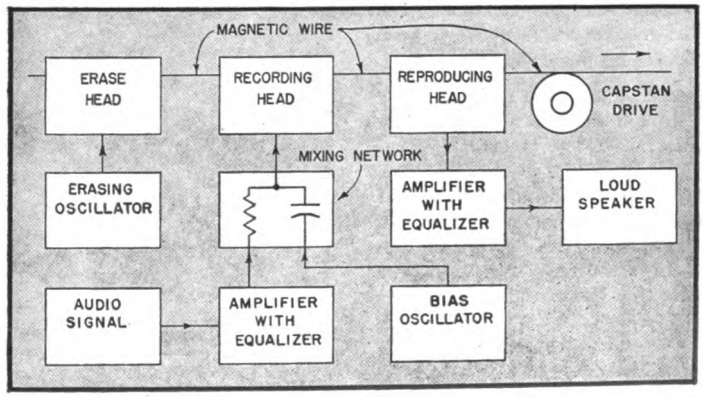


FIG. 1—Block diagram of an experimental magnetic recording system employing a supersonic bias field

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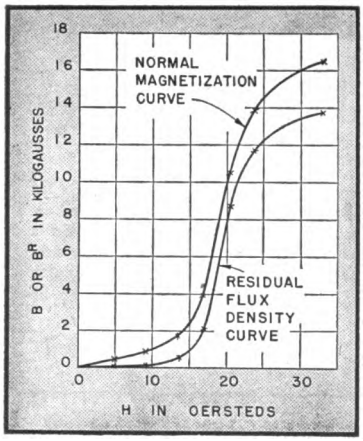

FIG. 2—Normal magnetization curve and residual induction curve for carbon-steel wire

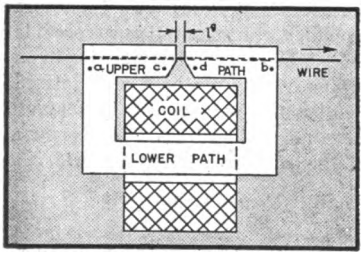

FIG. 3—Schematic diagram of a typical recording-reproducing head

bined action of the audio field and supersonic bias field from three points of view. In the first place, we shall examine the step-by-step relations as successive elements of the recording medium enter the recording gap. Next, we shall extend the analysis to show the averaging effect from point to point for a complete audio cycle. Finally, we shall show the analogy between these explanations and the commonly accepted graphical analysis for a pair of triodes in push-pull.

Magnetic Action of Supersonic Field

Figure 3 shows a schematic diagram of a typical recording-reproducing head. Let us now consider, step by step, the sequence of events taking place as a demagnetized element of the recording medium enters the recording gap from the seclusion of one of the poles, travels through the resultant field in the gap, and finally enters the slot in the second pole piece, where it is again shielded from the influence of the recording field.

The instantaneous value of field intensity in the gap, H_g, can be expressed as follows

$$H_g = H_A \sin(\omega_1 t + \theta_1) + H_B \sin(\omega_2 t + \theta_2) \quad (1)$$

in which H_A is the maximum instantaneous value of the field due to the audio signal

H_B is the maximum instantaneous value of the field due to the bias signal

ω_1 and ω_2 are the angular velocities corresponding to the frequencies of these signals

θ_1 and θ_2 are the relative phase positions of their respective signals

The graph of Fig. 4(a) shows curves of instantaneous values of field intensity in the gap, together with the audio component for a typical case.

Assume that the gap length is such that 1.5 cycles of bias signal will have been completed during the passage of the element of recording medium through the gap. This means that as each element passes through the gap, it will be subjected at least once to a field corresponding to the instantaneous audio signal plus the peak value of bias field in the same direction. The resultant maximum instantaneous field is the one which in large measure determines the value of the remanent flux density.

The graphs in Figure 4(b) illustrate three possible cases for successive elements entering the recording gap during a positive half-cycle of audio signal. Let us refer to the first of these graphs and consider in detail the phases through which an element of recording medium passes as it is subjected to the varying resultant field in the gap. Assume that the element enters the gap in a demagnetized state at time t_1, at which time the resultant field is zero. As the field rises to its first positive maximum value P, the flux density in the element follows the initial magnetization curve to point P'. Succeeding variations $PQRS$ in the resultant field cause the flux density to follow the path $P'Q'R'$ to S'. At this instant the element is assumed to start to enter the second pole piece, the resultant field acting on the element remanent flux density corresponds to the signal recorded on the element. The other two graphs represent the changes in flux density for elements entering the gap at t_2 and t_3. A linear system exists only if the values of remanent flux density are in direct proportion to the corresponding instantaneous values of audio signal.

It should be noted that this analysis differs considerably from a recently published explanation of the function of the supersonic bias

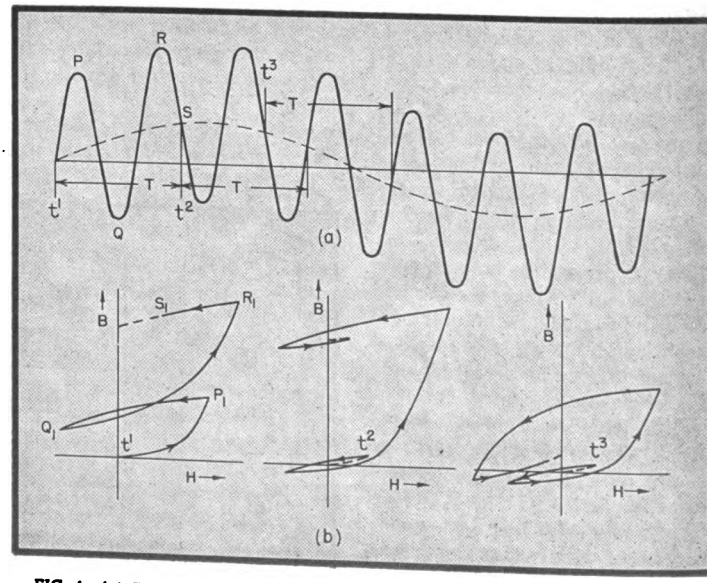

FIG. 4—(a) Curves of audio field and resultant supersonic field in the recording gap. (b) Curves showing assumed changes in gap field intensity acting on elements of recording medium

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field in that each of the curves in Fig. 4(b) starts from the origin and cannot be assumed to be a part of or attached to any hysteresis loop.[3] It is well-known that several cycles with constant maximum values of field intensity must be completed before the induction in a given magnetic material can be assumed to follow the same path around either a major or a minor hysteresis loop. In a practical case there is not enough time to produce a stabilized major loop because there is considerably less than one-half cycle of audio signal during the passage of an element through the gap. Neither can stabilized minor loops, due to the bias field, be assumed because for even a relatively high value of bias frequency only three or four cycles will be completed during the transit time of an element across the gap. Furthermore, the audio signal is never quite constant, even for this short time interval.

Analysis of Magnetic Transfer Characteristics

An extension of this step-by-step analysis to explain the averaging effect for a complete audio cycle is shown in Fig. 5. As shown in the block diagram of Fig. 1, the supersonic bias signal is mixed with the audio signal in a mixing network. The resulting current in the recording coil and field strength in the gap should be a simple mixed signal without modulation.

When no audio signal is present, the record on the wire will consist of a signal of supersonic frequency and of low amplitude. The amplitude will be low for two reasons. In the first place, the magnitude of the bias field is adjusted to a value which will just bring the operating point for zero audio signal up to the lower knee on the residual magnetization curve. The corresponding value of residual flux density for most ferromagnetic materials is low. In the second place, self-demagnetization is very pronounced at the supersonic frequency which is used for the bias field because this frequency corresponds to short magnet lengths on the recording medium. Thus the effective remanence is still lower than indicated by the curve under the condition of zero audio signal.

Now assume a sinusoidal audio signal to be superimposed on the supersonic bias field. Although in this case the combined signal recorded on the wire will have small variations corresponding to the bias frequency, it will have short time average values which are nearly proportional to the instantaneous magnitudes of the audio signal. The small variations are eliminated because any practical reproducer will not respond to the bias frequency.

This being the case, we can analyze the performance of the system during recording as follows. Referring again to Fig. 5, the positive peak values of resultant field are projected up to the residual-flux-density curve. The corresponding residual-flux-density values are plotted on the time axis at the right as curve *A*. The construction for the second positive peak is shown. The negative values are found in a similar manner and are plotted as curve *B*. The sum of curves *A* and *B* represents the residual flux density. If self-demagnetization can be neglected, this represents the flux signal recorded on the wire.

It can be seen that some distortion is still present, although the distortion has been reduced greatly from what it would have been without the bias field. Some further reduction could probably be obtained by a more judicious choice of bias and audio signals.

The distortion with high-level audio signals cannot be reduced by adjustment of the bias because this distortion is due to the upper bend of the residual-flux-density curve. An increase in the bias field beyond that giving minimum distortion with low-level audio signals only re-

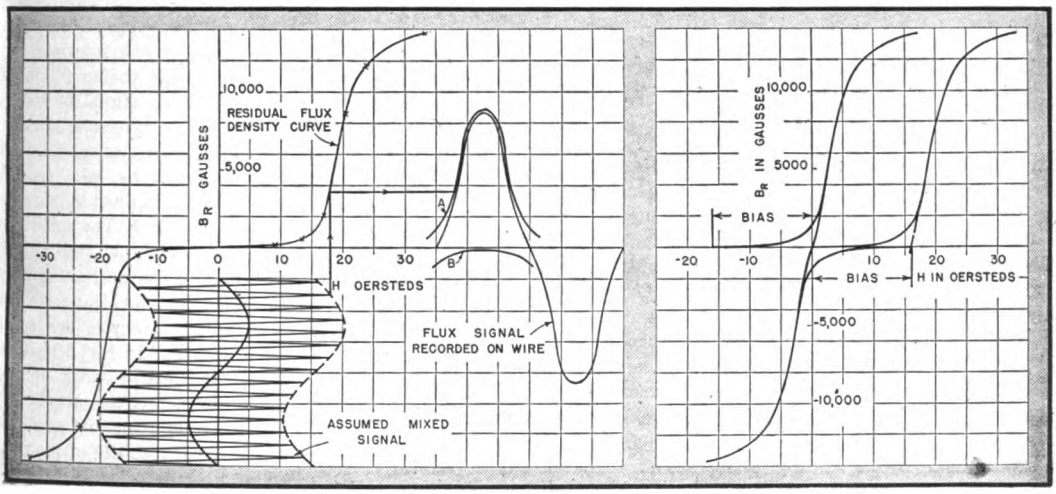

FIG. 5—Graphical analysis shows the combined actions of the audio and supersonic fields in the recording gap. Construction shows how recorded flux is obtained from combined magnetizing fields and magnetization curve

FIG. 6—Determination of correct bias field and construction of overall magnetic transfer characteristic

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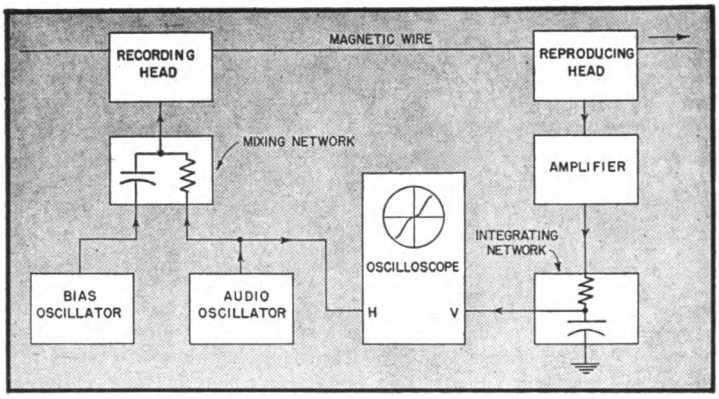

FIG. 7—Block diagram of the equipment for experimental observation of the overall magnetic transfer characteristic

sults in deterioration of the high-frequency response and reduction in the length of the linear portion of the over-all transfer characteristic. It is obviously desirable to have the linear portion of the over-all transfer characteristic long in order to have as large a dynamic range as possible.

The thought will probably occur to many readers that the above analysis is somewhat similar to the explanation of the operation of a pair of triodes as a class-AB push-pull amplifier. In accordance with this analogy, the proper value for the amplitude of the bias field can be determined by extending the steep portion of the residual-flux-density curve downward until it intersects the zero axis and reading the corresponding value of field intensity. The positive and negative portions of the curve can be shifted to the left and right respectively by the amplitude of the bias field, and the overall transfer characteristic can be considered to be the sum of the two portions. These relations are shown in Fig. 6.

Distortion Measurements

The non-linear distortion of a magnetic recording system can be evaluated in several ways. We have studied distortion by observing the transfer characteristic on an oscilloscope, by obtaining output-versus-input curves, by measuring intermodulation with two-frequency input, and by listening tests. We have not measured harmonic distortion, as we feel that this method gives little useful information.

The transfer characteristic can be observed on an oscilloscope if variations in the wire speed are very small. A signal from an audio oscillator is recorded on the wire in the usual manner and is also applied to the horizontal plates of the oscilloscope. The recorded signal is reproduced an instant later in a reproducing head located near the recording head, but well shielded from its stray-field influence. This signal is amplified and passed through an integrating network to the vertical plates of the oscilloscope. A block diagram for this setup is shown in Fig. 7. It is necessary to adjust the frequency of the audio oscillator so that the delay introduced while the wire travels from the recording head to the reproducing head is an integral number of half cycles. The integrating network is necessary because the output from the reproducing head depends upon the rate of change of flux through its magnetic circuit.

By use of this rather simple setup, the transfer characteristic can be observed while the amplitude of the bias or audio signal is varied, or the transfer characteristics of different wire samples can be compared. Photographs of transfer characteristics obtained in this way are shown in Fig. 8. The amplitude of the audio signal was great enough to produce overloading with correct bias, as is evident from the curvature at the ends of the transfer characteristic in Fig. 8(c). The loops in the oscillograms of the transfer characteristics are due to phase distortion in the amplifier and to slight instability of the wire speed and oscillator frequency.

Curvature of Transfer Characteristics

Output-versus-input curves are useful in finding out quickly the limit of input signal level, the corresponding magnitude of the output signal from the reproducing head, and the noise level. If these curves

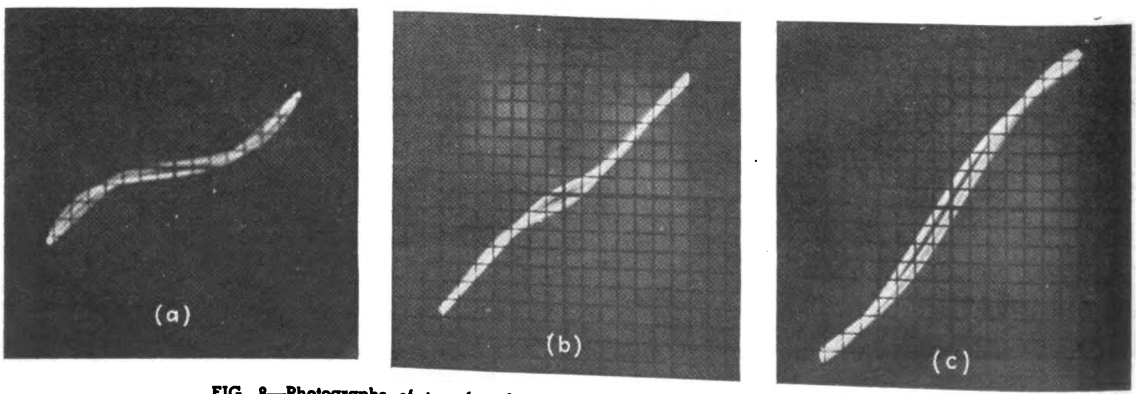

FIG. 8—Photographs of transfer characteristics as reproduced on an oscilloscope show the effect of supersonic bias; (a) no bias; (b) insufficient bias; (c) correct bias

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are plotted in decibels, they should be straight lines rising at a 45 degree angle over the range of input which gives linear operation. The point at which the curvature becomes appreciable is a fair indication of the maximum input signal that can be used and the maximum output signal available. Typical curves taken at several frequencies are shown in Fig. 9. It is apparent from these curves that the input current at which overloading starts is about the same at widely different frequencies. In some cases, however, overloading occurs with lower input levels at the higher frequencies. The use of these curves in determining signal-to-noise ratio will be discussed later.

Intermodulation measurements afford a more accurate method of determining distortion than either of the two discussed. This method consists of simultaneously recording two sine waves, one of low frequency and large amplitude and the other of high frequency and small amplitude, and of measuring in the output of the reproducing head any resulting modulation of the higher-frequency component by the lower.[2]

Figure 10 shows typical modulation envelopes of the high-frequency component for conditions of no bias, insufficient bias, and correct bias. The corresponding percentages of modulation are: 65 percent, 25 percent, and 32 percent, respectively. The oscillograms of the modulation envelopes were taken with the same peak audio signal and the same values of bias as the correspondingly lettered transfer characteristics in Fig. 8.

As mentioned before, overloading and consequent modulation occurred with correct bias because of the large amplitude of the audio signal. If the amplitude of the audio signal is reduced somewhat and the bias is left at the correct value, the transfer characteristic becomes nearly straight, the modulation envelope nearly uniform in width, and the percentage of modulation correspondingly low.

Procedure for Listening Tests

The listening test is the final criterion in judging a recording system. It has been found convenient to make listening tests by re-recording from high-quality vertically-cut Vinylite transcriptions. The pickup used is a Western Electric 9-A. The recording and playback amplifiers contribute a total of not more than about 4 percent intermodulation, and 1 percent harmonic distortion. The recording amplifier includes a flexible equalizer for both low and high frequencies. The playback amplifier includes a flexible low-frequency equalizer. A dual-coaxial speaker having substantially uniform response from 80 to 10,000 cps. is used. An additional high-quality amplifier fed from the same 9-A pickup is used for playing the transcriptions directly. Arrangements can be made for comparing the two systems on the same loudspeaker by quick switching. When using the magnetic wire loop tester there is sufficient delay between recording and reproducing so that the same phrase can be heard first from the transcription and then from the magnetic recording. This test gives much better comparisons than listening to an entire selection, first from a transcription and then from a magnetic recording. When the level of the two systems is the same, quick switching is the best method we know of for showing significant differences introduced by the magnetic recording system.

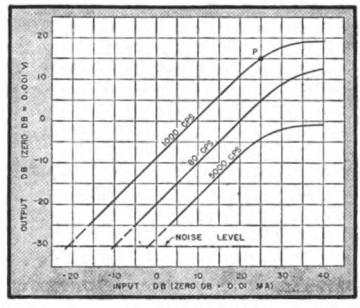

FIG. 9—Typical input-output curves for constant frequency show the range of linear response of the magnetic wire at various frequencies

Frequency Response

Magnetic recording is a phenomenon depending on current. The field intensity in the recording gap is nearly directly proportional to the mmf of the coil and this mmf is directly proportional to the current in the coil. The current in the coil can be made practically independent of the frequency of the input signal voltage by using a series resistance which is large compared with the reactance of the coil. With constant input voltage this should result in nearly the same value of field intensity in the gap for all fre-

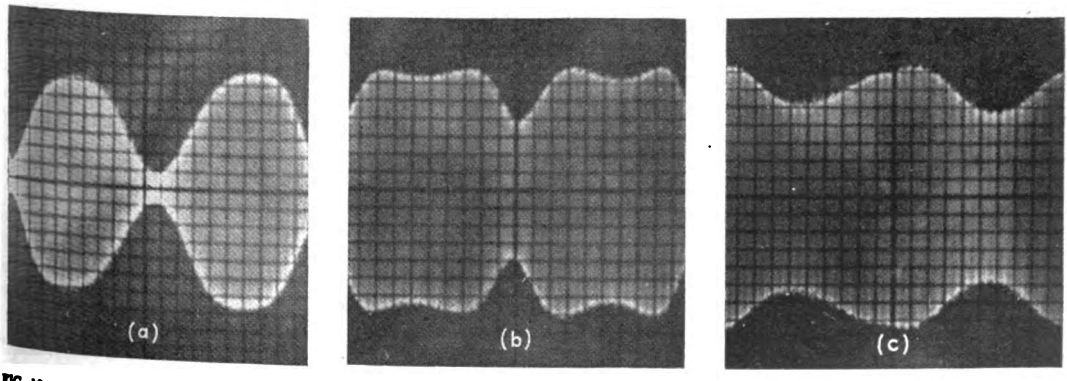

FIG. 10—The modulation produced by one audio frequency on another indicates curvilinear transfer characteristics. The greatest cross modulation occurs with no bias (a). As the bias is increased (b) the modulation decreases. Although the percent modulation shown at (c) is greater than at (b), fewer sidebands are produced, thus this condition represents the optimum supersonic bias

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quencies within the desired range. Unless otherwise specified, all of the frequency response characteristics to be discussed or shown represent the open-circuit voltage at the terminals of the reproducing head and are recorded with constant-current.

Under these conditions, if we disregard for a moment the serious demagnetization effect which takes place with short magnets, the magnitude of the residual flux density should be independent of the frequency. The length of the individual magnets is inversely proportional to frequency. Hence, as the frequency increases, the magnets become shorter. Because the flux lines must pass through the surface of the wire and through the air or other medium to a pole of opposite polarity, the surface density of the lines increases in direct proportion to the frequency, even though the maximum internal density across the sectional area of the wire may remain constant.

Effect of Air-Gap Length

The time rate of change of the lines leaving the surface of the wire at a north pole and returning through the magnetic circuit of the reproducing head to a nearby south pole determines the value of emf induced in the reproducing head. The maximum rate of change for a constant total number of lines is thus directly proportional to the frequency. This should produce a constant rise in output with frequency at the rate of 6 db per octave. Actually, this is found by measurement to be nearly true only at the lower frequencies. As the frequency is increased, the air-gap length in the reproducing head influences the frequency response according to the following equation:

$$E = KB_m S_w \sin\left(\frac{\pi l_g}{\lambda}\right) \qquad (2)$$

n which E is the rms voltage at the terminals of the coil
B_m is the maximum value of the remanence corresponding to the maximum instantaneous audio signal
S_w is the wire speed
λ is the wavelength corresponding to the audio signal recorded on the medium
l_g is the air gap length in the reproducing head
K is a constant depending on the units, and also upon the coupling between the wire and the magnetic circuit, as well as the size and configuration of the magnetic circuit, and on the properties of the reproducing coil itself

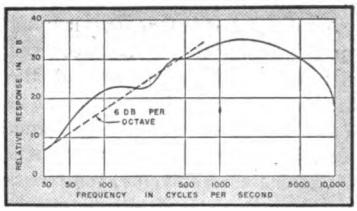

FIG. 11—Experimental frequency-response curve for constant-current magnetic recording

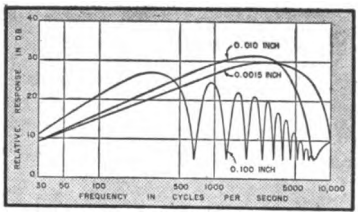

FIG. 12—Effect of gap length on frequency response

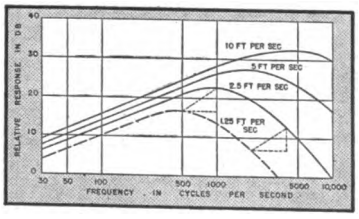

FIG. 13—Effect of wire speed on frequency response; solid curves were obtained experimentally, dashed curve was obtained graphically

At low frequencies sin $\pi l_g/\lambda$ is approximately proportional to the frequency and the output voltage should rise at the rate of nearly 6 db per octave. At higher frequencies sin $\pi l_g/\lambda$ is not proportional to the frequency and at a frequency such that $l_g = \lambda/2$, the output voltage reaches a maximum, then falls to zero when $l_g = \lambda$. The voltage again increases to a maximum at a frequency such that $l_g = 3/2\,\lambda$, falls to zero at $l_g = 2\,\lambda$, etc. A typical frequency response curve for constant-current recording is shown in Fig. 11.

The effect of using gaps of different lengths for the reproducing head is shown in Fig. 12. For the long gap there is much better correlation between the calculated and observed values of frequency at which maximum response occurs than with the short gaps. This is true for two reasons. In the first place, fringing effect causes a smaller percentage increase in the effective length of a long gap than of a short gap. Secondly, with a long gap, the demagnetizing effect is negligible at the frequency of the first maximum, whereas with a short gap, the demagnetizing effect tends to reduce the output voltage at the higher frequencies, resulting in a reduction in the frequency at which the first maximum response occurs.

Effect of Speed on Frequency Response

The speed at which the recording medium is driven has a pronounced effect on the high-frequency response of a magnetic recording system. On the other hand, the speed has only a slight effect at low frequencies. This is shown by the experimental curves of Fig. 13, which were all taken with the same input level. For simplicity the peaks and dips in the low-frequency region were averaged out when the curves were redrawn.

The more pronounced effect of speed on the high-frequency response is caused by self-demagnetization and by the relation between wavelength and gap-length. At low frequencies self-demagnetization is negligible, so that the remanent flux density is independent of wavelength and hence of the speed which, at any given frequency, determines the wavelength.

At the higher audio frequencies self-demagnetization is pronounced and, at a fixed frequency, increases rapidly as the speed is reduced. This results in a reduction in the high-frequency response. The high-frequency response also deteriorates when $\pi l_g/\lambda$ lies between $\pi/2$ and π. In a practical system, the wire speed is made such that this occurs near the upper end of the working frequency range.

Both of these effects are important, but the experimental determination of the relative reduction in response caused by either is difficult.

Assuming a given fixed wavelength recorded on the wire, the demagnetizing effect and the effect of the gap-length will be constant and

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independent of the speed at which the wire is driven. Both the output voltage and its frequency will then be directly proportional to speed. Knowing this, it is easy to find the constant-current frequency response at any wire speed from the response curve at a known speed by a simple graphical construction. A right triangle is drawn with its hypotenuse rising 6 db per octave. The length of the base is taken as the distance on the logarithmic frequency scale between two frequencies having the same ratio as that of the known speed to the speed at which the frequency response is desired. An example of this construction is shown in Fig. 13 where the dashed curve represents the frequency response at 1.25 feet per second as obtained from the response at 2.5 feet per second. The dashed curve is traced by the lower left hand corner of the triangle as the apex is moved along the response curve for 2.5 feet per second while the base is kept parallel to the zero axis.

Recording-Reproducing Heads

In spite of the fact that the frequency response for a given medium can be modified somewhat, especially at the higher frequencies, by changes in the design of the recording head, we find that these modifications are small as compared with those which occur with minor changes in the reproducing head. For practical reasons, it is desirable to use the same head for both recording and reproducing. Therefore the limitations imposed by the playback conditions are the ones which ordinarily control the design. The power required for recording is in the order of a few milliwatts, so that this does not impose any severe limitation on the amplifier design, even if a recording head with low recording efficiency is used.

For playback, the design of the reproducing head is very critical. The gap must be short in order to obtain good response at the higher audio frequencies. The material should have as high a permeability as possible at low flux densities. The eddy-current losses should be low in order that the high-frequency response will not be impaired. The magnetic coupling between the recording medium and the head should be good, especially in the immediate vicinity of the gap. On the other hand, the magnetic coupling between the recording medium and the head at the points of entry and exit should be kept as low as possible in order to reduce the magnitude of the secondary or stray flux which may produce certain undesirable variations in the frequency-response curve.

Effect of Coil Location

Let us consider the manner in which these undesirable variations are produced. If we refer again to Fig. 3, it can be seen that the passage of the wire through the slot in the reproducing head sets up an alternating magnetic potential between points *a* and *b*, and at the same time another alternating magnetic potential is set up between *c* and *d*. The magnetic potential between *a* and *b* reaches a maximum effective value at a relatively low audio frequency in a playback head of practical size. Alternate dips and peaks occur in the effective values of this magnetic potential at regularly spaced frequency intervals, depending upon the wavelength recorded on the wire relative to the effective width of the reproducing head. We shall call the flux due to this magnetic potential the secondary or stray flux.

There are two paths for this stray flux. One is directly across the top of the head and through the gap. The other is from *a* down through one of the vertical legs, across the lower leg and up the other vertical leg to point *b* in Fig. 3.

The alternating magnetic potential existing between *c* and *d* is the one which gives the useful response. There are also two paths for the flux produced by this alternating magnetic potential. One of these is directly across the gap. The other is around the complete magnetic circuit in a counter-clockwise direction for the positive values of magnetic potential.

Now consider the coil to be mounted as shown in Fig. 3. The resultant alternating flux and emf produced are the result of two alternating magnetic potentials. The useful component increases with frequency, according to the equation previously given. As mentioned above, the other component passes through several positive and negative peaks as the frequency changes over the audio spectrum. The total response will now show peaks and dips which become less pronounced as the frequency is increased.

If the coil is moved to a position where it surrounds the upper leg of the circuit, a similar response curve will result, except that the phase of the emf due to the stray flux is reversed, causing the positions of the peaks and dips to be interchanged. Experimental curves showing these effects are given in Fig. 14.

Correlation Between Magnetic Characteristics and Frequency Response

In the design of permanent magnets, great stress is attached to the proper shape and size of the magnetic circuit so that the permanent-magnet material may be used at or near the point of maximum energy. This makes the most efficient use of the costly alloys which are used for permanent magnets. Such a design is not possible for the case of a medium used for magnetic recording because the ratio of length to diameter for the individual magnets which make up the record varies from a value which is large at low frequencies to one which is less than unity at the higher frequencies.

The retentivity of the magnetic recording medium for a given wire speed determines the maximum value of the output voltage at the lower audio frequencies. At these frequencies the wavelength is relatively long and self-demagnetization is not serious. For this reason, one would expect to have good bass response for materials with high retentivity. A large number of our experimental frequency-response curves have shown this to be true.

The second magnetic characteristic which affects the frequency response to a very great degree is the coercive force of the material. The demagnetizing field intensity can be considered to be equal to the product of the demagnetization factor and the remanent flux den-

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sity. The demagnetization factor increases in magnitude as the ratio of the length of a permanent magnet to its diameter decreases. Whether or not the flux density is greatly reduced because of the demagnetization factor depends on the shape of the demagnetization curve, and especially upon the value of the coercive force.

The effect of demagnetization is less with materials having high coercive force. It is generally considered to be true that a magnetic material which has high coercive force will also have low retentivity. This is especially true of many of the materials which are being considered for use in magnetic recording. This means that we may have to sacrifice some output voltage at the lower audio frequencies in order to extend the upper frequency range by use of a material which has high coercive force but low retentivity.

Mechanical Sources of Noise

At the present time we cannot say that magnetic recording gives a system with negligible noise. We can say, however, that for a given reproduced-frequency bandwidth and for carefully controlled laboratory recording and reproducing conditions, the background noise is considerably less than that for the corresponding-frequency bandwidth on shellac records, but that it is not as low as the background noise on vertically-cut Vinylite transcriptions.

Mechanical imperfections in the wire which result in changes in sectional area along the wire may be responsible for the generation of noise voltages in the coil of the playback head. For a wire diameter of 0.004 inch, a variation in diameter of 0.0001 inch corresponds to an area change of about 5 percent. Corresponding changes in the recorded flux signal appear as noise when reproduced. If the variation in diameter is random, random noise will result. However, if the imperfections occur at regularly spaced intervals along the wire, a distinct tone will appear.

Either transverse or longitudinal vibrations of the medium as it is drawn through the reproducing head may also be the cause of undesirable background noise. These vibrations may be produced either by the irregular surface of the wire or by nonuniform torque anywhere in the driving system. These vibrations of the medium result in corresponding pulsations of flux linkages through the coil and a noise voltage in addition to the signal voltage appears at the terminals of the playback head.

Magnetic Noise Sources

We have found that although different wires may seem to be perfectly uniform in external appearance, they may vary considerably in noisiness. Some samples show an absolute noise level which is 20 db greater than that of some other samples. Although we have not yet been able to correlate the noise level with the composition, heat treatment, and degree of cold work used in preparing the samples, we think that it depends on the final magnetic structure which in turn is determined by these factors.

The magnetic noise increases in the presence of a recorded signal. This can be demonstrated by recording a sine-wave signal on the medium and filtering out the signal and its harmonics in the reproducing system. The reproduced noise will have frequency components distributed throughout the band passed by the filter. This noise increases as the amplitude of the recorded signal is increased and is reduced to a low value after the medium has been subjected to the erasing field. It seems probable that this noise is caused by the finite size of the elementary magnetic particles of the medium. A certain amount of such noise is not noticeable, as it is ordinarily masked by the signal. However, an excessive amount imparts a disagreeable fuzzy quality to the reproduction. It was pointed out earlier that any magnetic recording system using direct-current bias ordinarily leaves the recording medium magnetized even in the absence of an audio signal. In this case, the noise is particularly bad because there is no signal to mask it.

Equation (2) indicates that the noise voltage should increase with wire speed. This is confirmed by our measurements which show that the noise level rises at least 6 db each time the speed is doubled.

Another effect which may contribute to the noise is socalled crosstalk. This is the effect of adjacent turns or layers of the recording medium on each other when wound on a spool for storage. It is possible for one turn of strongly magnetized recording medium to magnetize an adjacent turn. This re-recorded signal may show up as objectionable noise, particularly during quiet passages of a selection where it would not be masked by the desired signal. Crosstalk can be reduced to a negligible amount by choosing a recording medium having low retentivity and high coercive force.

In considering noise, that originating in the reproducing system should also be mentioned. The signal output from a high impedance reproducing head is of the order of only a few millivolts, which makes it necessary to use a large amount of amplification. The amplifier must be carefully designed to minimize thermal noise and to be free from hum. In addition, the effects of stray electrostatic and electromagnetic fields on the reproducing head must be minimized by shielding or other means. The problem of eliminating hum is aggravated when post-equalization of the low frequencies is used. This is apparent from the fact that 15 or 20 db of equalization at 60 cycles is necessary in some cases for flat response.

Loss of Output Signal With Repeated Playings

There have been many general statements concerning the permanency of the records on magnetic wire. Much more information than we have at present is needed before we can make well-founded statements concerning the ability of the wire to retain a record indefinitely without loss. Experiments show that there is a loss of from 3 to 25 db in output from a given record during the first few playings. After this initial aging process there seems to be little further loss for a reasonable time and a reasonable number of playings. In general, materials which have properties desirable from other view-

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points tend to show small loss with repeated playings. As far as we know, no great difficulty has been experienced on account of this effect.

Equalization and Signal-to-Noise Ratio

Once the factors affecting the maximum signal and those affecting the noise have been determined, the problem of determining the effective signal-to-noise ratio remains. The effective signal-to-noise ratio depends not only upon the factors already discussed but also upon the frequency distribution of the noise, the frequency distribution of the speech or music to be recorded, and upon the amount of pre-equalization and post-equalization.

It has been accepted practice in some other fields to record with a characteristic rising toward the high frequencies and equalize in the reproducing circuits to give an overall flat response. It has been found that some increase in the signal-to-noise ratio can be accomplished by this practice. In the case of magnetic recording, however, it is not feasible to use a comparable amount of such pre-emphasis and post-equalization because at the speeds which are desirable for recording, the frequency response at the higher audio frequencies falls off very rapidly. However, even in this case, enough pre-equalization can be used to make the overall response flat within a specified frequency range. Post-equalization for increasing the high-frequency response is not desirable, because the objectionable noise has been found by rough measurements and by listening to occur largely at medium and high frequencies. Post-equalization would amplify the noise as well as the signal.

Due to the fact that, in reproduction, the low-frequency response of the system is inherently lower than the response in the middle-frequency range, some form of bass equalization must be used. It is not feasible to use sufficient pre-equalization to obtain even flat overall response because the wire will not accept the resulting large recording signals without overloading. A sufficient reduction of the recording level to permit the use of pre-equalization would result in a less favorable signal-to-noise ratio. On the other hand, post-equalization is feasible because the amount of noise in the low-frequency region is small.

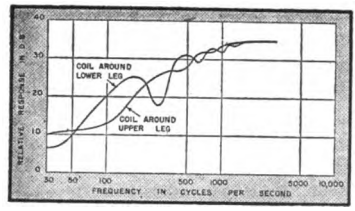

FIG. 14—Experimental curves showing that peaks and dips in the frequency response are dependent upon coil placement

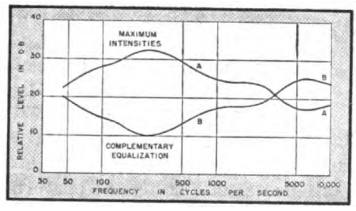

FIG. 15—Curve *A* shows frequency distribution of maximum sound intensities for a symphony orchestra. Curve *B* shows the desired complementary pre-equalization.

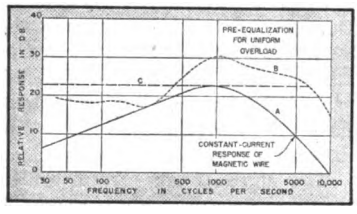

FIG. 16—By using a pre-equalization network having the characteristics of curve *B*, which is the sum of curve *A* in this figure and curve *B* in Fig. 15, overloading of the magnetic tape is equally likely to occur at all frequencies

Equalization Against Overload

The following example serves to illustrate the application of these principles to a practical magnetic recording system. Curve *A* of Fig. 15 represents the frequency distribution of the maximum intensities occurring in symphony orchestra music.[2] This curve is drawn at a level which is exceeded by 5 percent of the peaks and can be used as an indication of the relative levels which must be accommodated by the system at various frequencies. Having this information, it is possible to decide upon the amount and type of equalization which will result in the highest signal-to-noise ratio, and to arrive at the approximate value of the signal-to-noise ratio.

From curve *A* of Fig. 15 it is apparent that with constant current recording the system will overload most often at about 250 cps. In order to make the most effective use of the system it would be desirable to have overloading occur equally often at all frequencies. This can be done by using pre-equalization which is complementary to curve *A* of Fig. 15, as shown by curve *B* of the same figure.

Passing on to Fig. 16, there is shown (curve *A*) a typical, smoothed constant-current response curve. This is the curve at 2.5 feet per second replotted from Fig. 13. If we now take the complementary equalization curve *B* of Fig. 15 and add it to this constant-current response curve we obtain curve *B* of Fig. 16 representing the over-all frequency-response of a system which has equal probability of overloading at all frequencies under the conditions assumed. This curve is obviously unsatisfactory from the standpoint of frequency-response, but is useful as a guide in determining the maximum amount of pre-equalization that may safely be used. For example, a useful amount of pre-equalization may be employed below about 250 cps and the remaining equalization found necessary to secure flat over-all response may be applied to the reproducing circuits. We have found that such low-frequency post-equalization does not appear to raise appreciably the random-noise level.

Upper Frequency Limit

Turning now to the upper portion of the frequency range we find that, without loss in signal-to-noise ratio, the high-frequency response can be made flat out to the frequency at which the uniform overload curve intersects a flat response line *C* drawn through the highest level of the constant-current response curve. The signal-to-noise ratio can then be taken as the difference between the level of the maximum undistorted output signal at the frequency of maximum response and the noise level. If it is desired to extend the frequency range, this can only be done with a

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sacrifice in signal-to-noise ratio.

For example, with the system for which curves are shown, when the high-frequency response is made flat up to 6500 cps, the maximum inherent capacity of the system can be utilized. If the flat response is extended to 9000 cps a loss of 5 db in signal-to-noise ratio will result. This loss is the difference between the level of the flat-response line drawn through the maximum level of the constant current curve and the ordinate of the uniform-overload curve at 9000 cps.

The maximum undistorted signal can be defined for the present purpose as that at which the output-versus-input curve for the frequency of maximum response departs 1 db from linearity. This is represented as point *P* on the 1000-cycle curve of Fig. 9. For the curves shown, the signal-to-noise ratio according to our definition would be 45 db for flat response to 6500 cps, and 40 db for flat response to 9000 cps.

The foregoing example tends to give an optimistic picture of the performance under the assumed operating conditions first, because it has been assumed that overloading occurs at equal input level regardless of frequency, and second, because it does not take account of magnetic noise. We have observed that overloading in some cases begins to occur with lower input current at the higher frequencies. The difference between the input level for maximum undistorted output signal at the frequency of maximum response and the corresponding value at the highest frequency in the assumed band must be subtracted from the signal-to-noise ratios obtained by the above method. For the example shown, however, this subtractive term amounted to less than one db at 5000 cps, which is negligible. Other measurements have shown that some materials show up to 15 db increase in their magnetic noise level with increase in recording signal. The sample for which the curves are shown was rejected on this account when a listening test was made.

The importance of judging a magnetic recording system by means of a critical listening test cannot be over-emphasized. Objective measurements such as frequency response, distortion, and noise measurements are invaluable in making a preliminary estimate of the quality of any component of a recording system and in pointing the way to improvements. However, the correlation between objective measurements and subjective effects is complex and not completely understood. Therefore, the listening test must always be used as the final criterion.

Magnetic Recording Possibilities

Our studies in connection with magnetic recording systems lead us to make the following general statements concerning the performance of present experimental systems and possible future improvements in magnetic recording systems.

Reasonable fidelity is possible at the present time. In order to get a system with low distortion, careful control of the bias field is necessary. The correct value of the bias field varies within wide limits for different recording media.

The signal-to-noise ratio which can be attained at present is superior to that which is obtained from the ordinary shellac disc recordings. It is not as good as can be obtained from the newest vertically-cut Vinylite transcriptions. We expect that improvement in the signal-to-noise ratio will result from further studies in connection with noise and that this will lead to improved recording media and improved design of the recording and reproducing heads.

It seems feasible at the present time to produce recordings at 2.5 feet per second on 0.004 inch diameter wire which are reasonably flat from 70 to 6500 cps. While the upper limit of frequency response may be raised by increasing the wire speed, it would appear more desirable to attempt to get better high-frequency response by improving certain magnetic properties of the recording medium. Actually it would be far more satisfactory from the viewpoint of cost to the consumer if the wire speed could be reduced to a still lower value, say 2 feet per second, or even 1.5 feet per second. These lower speeds seem to be quite satisfactory for the reproduction of speech. There are indications that improved design of the recording and reproducing heads will be necessary in order to utilize fully the newer materials which are being investigated for possible use as magnetic recording media.

In conclusion it should be pointed out that we are not attempting to specify any definite standards for magnetic recording at this time. The examples which have been presented are given simply for the purpose of illustration and do not necessarily represent our ideas as to the most desirable frequency limits, limits of distortion, or wire dimensions, and speeds. The experimental frequency - response curves which have been given represent average, rather than superior, samples and they were made without using special recording and reproducing heads.

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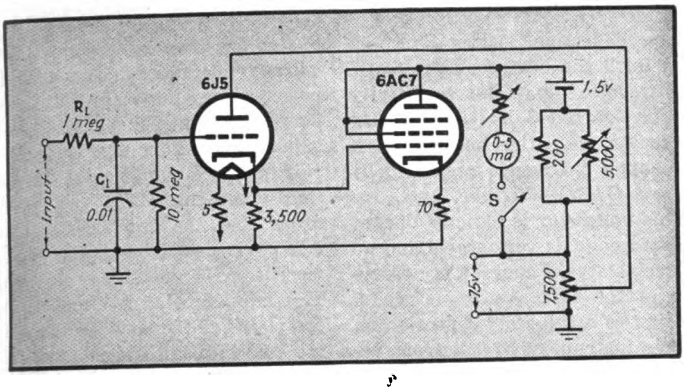

FIG. 1—Direct-current vacuum-tube voltmeter using a high-transconductance pentode isolated from the high-impedance input circuit by a triode connected as a cathode follower

Improved VACUUM-TUBE VOLTMETERS

Full advantage can be taken of the high transconductance and linear transfer characteristics of pentodes by using a cathode-coupled triode in the vacuum-tube voltmeter input. Such a combination provides an instrument having both high input impedance over a wide frequency range and high sensitivity

By J. T. McCARTHY
Assistant Professor of Physics
Western Reserve University
Cleveland, Ohio

MANY VACUUM-TUBE VOLTMETERS employ a d-c microammeter as an indicator, with 1.5-volts input giving a deflection of 100-200 microamperes. The sensitive indicating instrument is needed because, (for reasons of stability, linearity, and low grid-current) the amplifier tube is operated in a region of low transconductance, with large degenerative feedback. When the feedback is great enough, calibration can be made nearly independent of tube characteristics and changes.

Microammeters have been improved in recent years so that they are no longer regarded as expensive and fragile instruments. Many voltmeters employing them seem quite satisfactory. However, it appears that a milliammeter would still have advantages when expense, durability, and availability are important. Furthermore, a stable voltmeter built to operate with a milliammeter at 1.5 volts input could have its range extended downward by the use of a more sensitive indicator.

Need for Greater Amplification

In order to use a less sensitive indicating instrument the vacuum tube must be operated in a region where its transconductance is high. Less degenerative feedback may be used but less is needed (for linearity at least) because the characteristic curve is more linear in this region. Although the use of television-type pentodes for voltmeters has occurred to several workers in the field, a tube of this type biased at a suitable operating point suffers from a rather large flow of grid current. This causes the input impedance to be low and produces an error in reading, the degree of error depending upon the impedance of the source.

Turner[1] has not only pointed out in detail the types of tubes with high transconductance that might be used for voltmeters but has also suggested that high effective-transconductance could be obtained by operating two or more tubes in parallel. However, parallel operation of tubes suffers from two disadvantages: first, the input capacitance and conductance are multiplied; and second, the total plate current increases greatly, so that more is demanded of the power supply.

Yard[2] has used a high-transconductance tube in a conventional circuit and obtained a deflection of

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5 ma for 1.5 volts input. The deflection can be doubled by using a separate battery or cell to balance out the initial plate current. This circuit suffers from a lack of linear response, a shift of the zero-setting with line-voltage fluctuations, and a low input impedance of about 1.5 megohms. The grid resistor cannot successfully be increased very much because of the flow of grid current. These difficulties are probably inherent in any voltmeter employing a single tube of high transconductance or two or more tubes in parallel.

Cathode Coupling

It will be shown below that high-transconductance tubes can be used successfully in simple and inexpensive voltmeter circuits when some kind of input stage is used to provide high input resistance. High sensitivity and large output current result. The disadvantages accompanying small degenerative feedback are minimized by using balanced circuits and some means for quick calibration.

The circuit in Fig. 1 was designed to overcome, by sacrificing some simplicity, the short-comings of the single-tube voltmeter. This d-c voltmeter is essentially a two-stage amplifier with the first stage serving only to couple the source to the second tube. The first stage is a cathode-follower arrangement and is highly stable because of the large degeneration. The 6J5 is operated with low voltages on the heater and plate in order to reduce the grid current in both tubes. The high side of the input is connected through a shielded lead with a 1-megohm isolating resistor, thus providing an input resistance of 11 megohms. This resistance could be made larger.

Meter Characteristics

The bias for the 6AC7 is the algebraic sum of the voltage drops across the two cathode resistors. The initial plate current is balanced out by a No. 6 dry cell. Instead of this cell, a suitable voltage may be tapped from the bleeder resistance but this reduces somewhat the sensitivity. In order to protect the indicating instrument against excessive deflection, switch *S* is left open until the heater of the 6AC7 has warmed up. The sensitivity can be controlled by the rheostat in series with the milliammeter. The supply voltage is regulated by using a OA3/VR75 tube.

This voltmeter is strictly linear; the zero point is very stable and no appreciable grid current is observable in the 6J5. An input of 1.5 volts gives a full-scale deflection on a 5 ma instrument of 1 percent accuracy. The circuit is sufficiently stable so that, by means of a more sensitive indicator, the range of the voltmeter may be extended downward by a factor of two or three at least, depending upon the voltage fluctuations in the power line. The range may be extended upward by a conventional voltage-divider across the input. Because of the filtering action of the input circuit, d-c voltages can be measured correctly even in the presence of superimposed a-c voltages.

Balanced Circuit

This type of coupling can also be applied to a balanced circuit to avoid employing a dry cell and to stabilize more easily against line-voltage fluctuations. A stabilized power supply is usually not necessary and some simplification results. This is illustrated by the circuit in Fig. 2, a stable circuit with linear response. The two 6AG7 tubes and the two sides of the 6SN7-GT should be approximately matched for optimum stability. The milliammeter is connected to the plates of the amplifier tubes in the conventional bridge circuit. A deflection of 10 ma can be obtained for an input of 2 volts but the circuit is usually operated conservatively with the constants shown so that 1.5 volts produces a reading of 5 ma. When a 1-ma meter is used, satisfactory performance is obtained with a full-scale deflection corresponding to 0.3 volt. Slight effects of line-voltage fluctuations are observable at this sensitivity.

Although other types of tubes were tried in this circuit, the 6AG7 gave maximum sensitivity. The response with 6AC7's is only slightly lower however, and these tubes have the advantage of lower plate current (20 ma for two 6AC7's instead of 35 ma for two

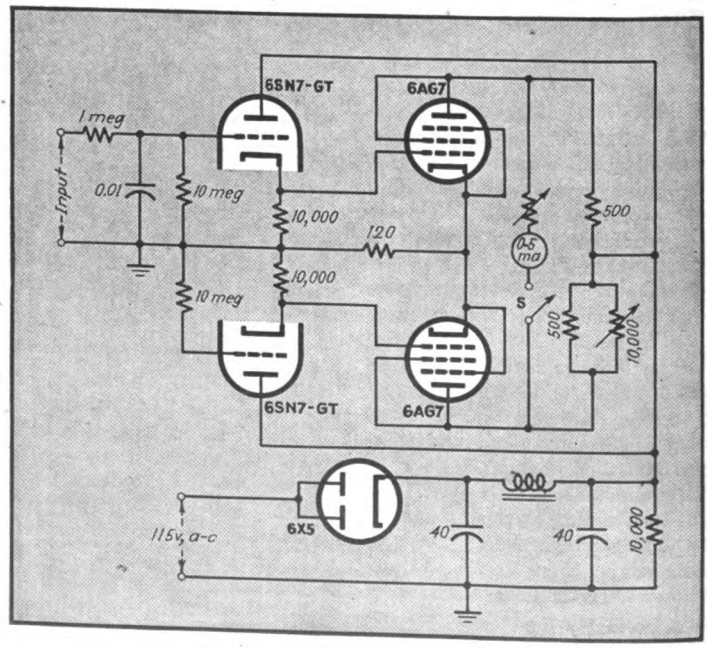

FIG. 2—Balanced voltmeter circuit uses cathode coupling and high-transconductance pentodes

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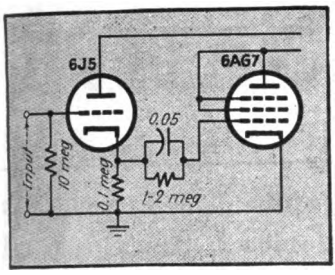

FIG. 3—Alternating-current vacuum-tube voltmeter with a cathode-coupled stage preceding the high-transconductance pentode grid-detector stage

6AG7's). At high plate current 50L6-GT tubes worked fairly well. A 6F8-G, with similar characteristics, might be preferable to the 6SN7-GT because higher input resistance could be obtained to the grid coming out of the top of the tube. It is possible that a selection of tubes with suitable heater ratings could be made in order to dispose of the filament transformer, to use cheaper tubes and to allow complete operation on a-c or d-c lines.

A-C Measurement

This type of circuit can easily be adapted to the measurement of a-c voltages. If R_1 and C_1 of Fig. 1 were removed, the insertion of a diode rectifier either before or after the first stage should work well and provide a linear scale. If placed after the first stage, the high input impedance of the circuit would be retained. An even simpler arrangement would be to allow rectification to take place in the first stage. This tube would then become what Rider[3] calls a reflex rectifier, or what radio publications often call an infinite-impedance detector.

In one adaptation to a-c that was tried, the grid circuit of the second stage was used as a rectifier, as illustrated in Fig. 3. With a 6AC7 tube, a deflection of 5 ma for 1-volt rms input is obtainable. The response is linear except over the very lowest part of the scale. Although this circuit was used only at audio frequencies, it has recently been shown by Daniels[4] that the cathode-follower circuit can be used up to several hundred kilocycles in voltmeter circuits without using an external probe.

By using ordinary triodes in all four arms of a Wheatstone-bridge circuit, Glenn[5] has constructed a voltmeter which can operate a 1-ma instrument on less than 0.5 volt input. Stability and high input resistance are claimed along with this high sensitivity. Instruments of higher range are not suitable for this circuit because all tubes must be operated at very low plate currents in order to avoid a large grid current in the input tube.

Wheatstone Bridge

The circuit shown in Fig. 4 is similar to that of Glenn, but contains the added resistors R_1 and R_2.

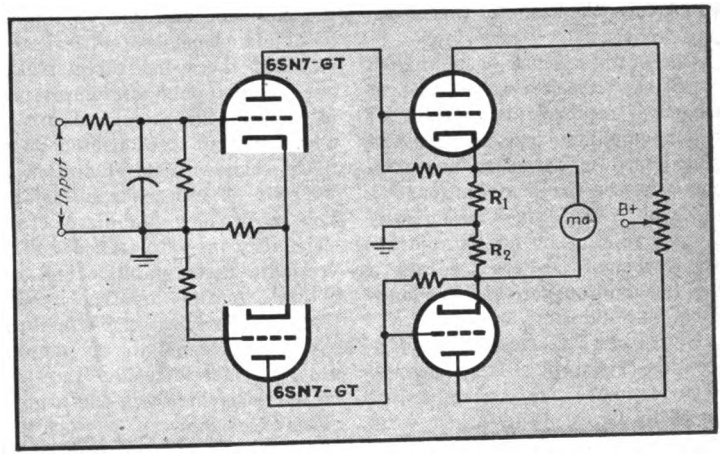

FIG. 4—Wheatstone-bridge balanced vacuum-tube voltmeter circuit combines high sensitivity and stability

The latter increase the power output greatly, especially when power tubes are used in the second stage. When tubes like 6V6-GT, 6L6 and 6AG7 are used at very conservative plate currents, a maximum deflection of 15 to 25 ma for 1.5 volts input is easy to obtain. Preliminary experiments have shown that the output can be made linear over the first 5 or 10 ma and that practical stability is possible. The use of separate resistors in the cathode circuits of the first stage is desirable.

Line-Voltage Compensation

Although balanced circuits like those of Fig. 2 and Fig. 4 are advantageous, complete compensation for line-voltage fluctuations is not attained in them. The difficulty arises from slight differences in dynamic characteristics and in heater characteristics of similar tubes and should be more prominent in circuits like those shown above, especially when little or no degenerative feedback is used. However, it was found that power-line fluctuations in our laboratory caused a negligible error in reading when balanced circuits were used. For cases where these fluctuations are larger or where a more sensitive indicating instrument is to be used, greater stability could be obtained by using a stabilized power supply or a constant-voltage transformer.

It can be expected in the above circuits that the calibration, depending more than usual upon tube characteristics, will change slightly as the tubes age. The inclusion of a Mallory bias cell in a voltmeter allows a frequent and rapid check upon this calibration.

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Stabilized NEGATIVE

Negative impedance is produced from a positive impedance of the desired type by positive feedback through an amplifier stabilized with negative feedback. Basic circuits and fundamental equations indicate the regions and limits of stability for ideal conditions

By E. L. GINZTON

Research Engineer
Sperry Gyroscope Company, Inc.
Garden City, N. Y.

INVERSE FEEDBACK is one of the most important developments in communication-network technique since the invention of the vacuum tube. Evolution of this principle can be traced along several independent courses two of which form the basis for this three-part article.

One of these courses culminated in Black's[1] disclosure in 1934 of negative feedback by means of which amplifiers can be stabilized and improved in many ways. A somewhat earlier contribution was made by Aiken[2], and Crisson[3] who discovered that by an appropriate application of positive feedback a two-terminal negative impedance could be obtained.

By combining the stabilizing feature described by Black and the negative-impedance concept introduced by Crisson and Aiken, it is possible to obtain a negative impedance that can be used as a stable circuit element. Thus by adding negative resistance, negative capacitance, and negative inductance to the list of positive impedances, the engineer now has at his disposal six elements for design instead of the usual three, making possible not only an improvement in some of the present circuit applications, but also opening an entirely unknown field of design.

The first two parts of this article show how stabilized circuit elements can be obtained and investigate their stability and reliability. A few practical applications are described in the final part —not to give an air of completeness, but merely to illustrate some of the ways in which the negative circuit elements can be used.

A positive resistance R is defined by Ohm's law as the constant of proportionality between the voltage across and the current flowing through that resistance. That is, $R = E/I$ where E and I are voltage and current, respectively. According to Joule's law, power will be dissipated in resistance R at rate P where $P = I^2R$.

Nature of Negative Resistance

From these two laws a definition of negative resistance may be formed. If R is replaced by $-R_n$, it will be seen that Ohm's law will still hold, for voltage and current will still be proportional to each other. Joule's law will state, however, that instead of dissipating power, the negative resistance will generate power, introducing it into the circuit at the rate I^2R_n.

Obviously, if any device is to show a negative-resistance characteristic, it must contain a source of power, such as a battery, and a means of controlling that power source so that Ohm's law will be followed. Since, in any practical case a source of power is limited, the negative-resistance characteristic will be shown by the device only over a limited range of voltage or current.

Negative Reactances

The definition of negative inductance and negative capacitance may be formed analogously. The reactance of inductance X_L is defined by an extension of Ohm's law to alternating currents. Thus $X_L = E_L/I = j\omega L$ where E_L is the voltage across the inductance, I is the current through the inductance, and L is the inductance in henrys. As is shown by this relation, a positive inductance is one whose re-

PART I

Basic ideal circuit and fundamental equations for producing the negative of a positive impedance. Eq. (1)-(29), Fig. 1-9, Ref. 1-10

PART II

Effect on negative impedance of variations with frequency of amplifier parameters. Eq. (30)-(56), Fig. 10-20, Ref. 11-13

PART III

Illustrative applications of negative impedances show how improved circuits can be obtained. Eq. (57)-(67), Fig. 21-27, Ref. 14-16

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IMPEDANCES . . . Part I

actance increases with frequency.

If L is replaced by $-L_n$, the impedance is $\omega L_n/j$. This equation may be used as a definition of a negative inductance. Thus, it is seen that a negative inductance is equivalent to a capacitive reactance whose magnitude increases with frequency.

A negative capacitance may be defined in the same way. It will be found that a negative capacitance is equivalent to an inductance whose reactance decreases with frequency.

In passing, it should be noted that positive and negative inductances and positive and negative capacitances can store energy equally well. But in the case of the negative impedances, the amount of energy that can be stored is limited by the amount of voltage or current that the negative-impedance-producing element can supply.

Because amplifiers will be used to produce the negative impedances it will be necessary to consider their limits of linearity and power handling capacity. This consideration will be taken up in Part II; for the present we will assume that an amplifier which is linear within the range of operation required for the production of the required negative impedances can be built.

Negative Resistance Sources

There are many sources of negative resistances known at present. Some of them occur in natural phenomena such as in gaseous discharges, others are produced by artificial means such as a source of energy and a control device arranged to maintain current and voltage in their required ratio.

An example of the latter is a direct-current series generator which shows a negative-resistance characteristic because current flowing through the generator excites its field and the generator produces a voltage which tends to increase the current.

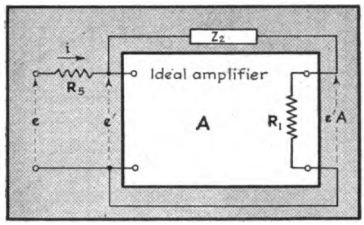

FIG. 1—Circuit for producing shunt negative impedance across its input terminals

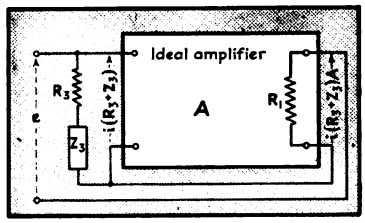

FIG. 2—Circuit for producing series negative impedance across its input terminals

Sources of negative resistance which are useful in communication circuits were described by Herold[4] and others. Some of these are: Arc discharge, the dynatron, retarding-field type of negative resistance[5], a space-charge grid tube which operates with a temperature-limited cathode, the split anode magnetron, and a low gas-pressure triode.

None of these methods of obtaining negative resistances are capable of producing pure negative reactances. Moreover, examination of the various methods reveals that in most cases the resistance is not linear, but depends greatly upon the magnitude of the applied voltage or current.

A different method of obtaining negative circuit elements has been suggested by Crisson, Dudley, and Mathes by means of which it is possible to obtain linear negative resistances of any value whatever and also pure negative reactances. The following section will discuss the methods suggested by Crisson.[3]

There are two ways in which it is possible to obtain negative impedance provided a positive of this impedance can be constructed in the form of a two-terminal network. The two methods can be used to produce the same impedance, but it will be found that only one of them can be used in any particular application. This consideration will be discussed in greater detail later.

First, equations will be determined for the input impedances of the two circuits which have been found to give negative impedances. This analysis will indicate the range and limiting factors of the negative impedances so produced.

Shunt Negative Impedance

Consider the amplifier shown in Fig. 1. The square labelled A represents an ideal amplifier with a voltage amplification A and an output resistance R_1. (Output impedance R_1 in this paper will mean the impedance looking into the output terminals of the amplifier. It is not necessarily equal to the physical output impedance of the amplifier because it may be affected by the presence of negative feedback in the amplifier.)

By an ideal amplifier is meant an amplifier which has a uniform frequency response from zero to infinity cycles per second, infinite power handling ability, zero phase shift for all frequencies, and an output resistance R_1 which is independent of frequency.

Let

- e = voltage applied to the amplifier
- e' = voltage at the input terminals of the amplifier (see Fig. 1)
- Z_2 = any positive impedance, the negative of which it is desired to obtain
- R_s = a resistance placed as shown in Fig. 1
- i = current taken from the source of voltage e

The circuit shown in Fig. 1 may be rearranged by means of Thevénin's theorem. If this is done, the output of the amplifier as shown in Fig. 1 may be replaced by the equivalent voltage $e'A$ in series with the output resistance R_1. With

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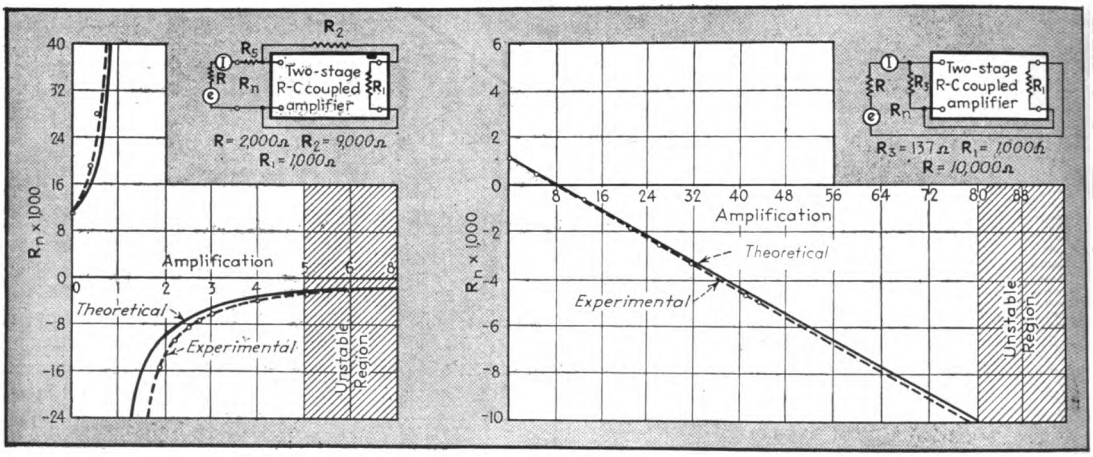

FIG. 3—Gain of amplifier determines magnitude and sign of negative resistance produced across its input although a single positive resistance is used

FIG. 4—A wide range of negative resistances can be produced by choice of amplification and of either shunt or series circuits

this transposition in mind, the following relations can be written. The net voltage acting across the output impedance R_1 and impedance Z_2 is $(e' - e'A)$, according to the convention of polarities of voltages indicated in Fig. 1 by means of arrows. Hence, the current that flows through R_1 and Z_2 in series is

$$i = \frac{e' - e'A}{Z_2 + R_1} = \frac{e'(1 - A)}{Z_2 + R_1} \qquad (1)$$

Solving for e'/i

$$\frac{e'}{i} = \frac{Z_2}{1 - A} + \frac{R_1}{1 - A} \qquad (2)$$

This ratio represents an impedance at the amplifier terminals where e' is measured. The impedance offered to the source of voltage e must be the sum of R_5 and this apparent amplifier input impedance. Defining the impedance offered to the source e by the entire circuit as Z_n

$$Z_n = e/i = R_5 + e'/i$$

$$Z_n = R_5 + \frac{Z_2}{1 - A} + \frac{R_1}{1 - A} \qquad (3)$$

If R_5 is adjusted so that $R_5 = R_1/(A - 1)$, then $R_5 + R_1/(1 - A) = 0$, and therefore Eq. (3) becomes

$$Z_n = Z_2/(1 - A) \qquad (4)$$

If the amplification A is positive and greater than unity, then the input impedance of the circuit of Fig. 1 is negative and determined in character only by the nature of Z_2. Crisson attributes this type of a negative impedance to Dudley and for reasons which will be explained later calls this type of negative impedance the *shunt negative impedance.*

Series Negative Impedance

The second method of obtaining negative impedance is illustrated in Fig. 2. In this case Z_3 is the positive impedance the negative of which is the desired result. R_3 is a resistance whose function is similar to that of R_5 in the previous case.

If e is the voltage applied at the terminals of the circuit as is shown in Fig. 2, then a current i will flow through the circuit. The following equation can be written.

$$e = i(R_3 + Z_3 + R_1) - i(R_3 + Z_3)A \qquad (5)$$

From which

$$Z_n = (e/i) = Z_3(1 - A) + R_3(1 - A) + R_1 \qquad (6)$$

If R_3 is adjusted so that $R_1 = R_3(A - 1)$, then $R_1 + R_3(1 - A) = 0$, and therefore

$$Z_n = Z_3(1 - A) \qquad (7)$$

If A is positive and greater than unity, the input impedance of the circuit is negative and determined in character only by the nature of Z_3. This type of a negative impedance is called a *series negative impedance.* Crisson attributes its discovery to Mathes.

From the preceding discussion it is evident that by means of application of positive feedback in an ideal amplifier it is possible to obtain negative impedances without depending upon natural phenomenon such as gas discharge or secondary emission, or upon a device which may be inherently nonlinear.

Reliability

The elementary picture given above is not sufficient for a practical application of negative impedances. One can readily observe that both of these circuits are essentially members of the same family and involve positive feedback, and one would be rightly justified in raising the question of stability and how the deviations from the assumed ideal amplifier will affect its performance. These questions will be discussed later where it will be shown that negative circuit elements can be made to possess extraordinary stability, and that the deviations of an actual ampilfier from the ideal modify the results only in special regions.

In addition to the positive feedback that is obviously necessary to obtain the negative impedances, the amplifiers themselves can be stabilized with negative feedback. It will be shown that simultaneous application of positive and negative feedback in an amplifier may be made use of to produce negative impedances which are just as sta-

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ble and reliable as ordinary commercially available circuit elements. Nor in this simultaneous application of positive and negative feedback does the effect of one cancel the effect of the other. Amplifier gain does, however, play a major part in determining the magnitude and stability of negative impedance. The effect is different for negative impedances produced by the two methods, as the following considerations will show.

Amplifier Gain in Shunt Circuits

If the amplification in Fig. 1 is zero, the input impedance offered to the source of a voltage e is the sum $(R_s + Z_s + R_1)$, and the current flows from the source of voltage, being entirely determined by this sum. If A is increased positively from zero towards infinity, the current will decrease and when A is of such a magnitude that the output voltage of the amplifier just equals e, the current must be zero and therefore the input impedance Z_{in} must be infinite. This is also observed from Eq. (3) and (4), because when $A = 1$, Z_{in} becomes infinite.

If A becomes greater than unity, the current reverses and flows into the source of voltage e and the circuit exhibits negative impedance characteristics. When A reaches a value so that the resultant current flowing into the voltage source e supplies all the losses in its path, oscillations will result.

An example of this kind of a negative impedance is illustrated in Fig. 3, where Z_s was chosen to be a pure resistance so that the input impedance of the amplifier is a pure negative resistance. The shaded region indicates the values of A for which the amplifier is unstable and in which case current is limited only by the power handling ability of the amplifier. It is seen from Fig. 3 that the negative resistance supplied by the amplifier in the stable region is greater in magnitude than the resistance R in parallel with which it is connected, and approaches an open circuit.

It should be observed at this point that a combination of a positive resistance in parallel with a larger negative resistance results in a positive resistance, although the series combination of the same two resistances will result in a negative resistance.

From interpretation of the performance of the circuit it was found that the arrangement of Fig. 3 is stable as long as the negative resistance supplied by the amplifier is greater than the positive resistance across which it is connected, i.e., in the region where the parallel combination of the two is positive. Because of this phenomenon, the type of the negative impedance supplied by the arrangements shown in Figs. 1 and 3 is called a shunt negative impedance.

Amplifier Gain in Series Circuits

The situation in the case of Fig. 2 will be found to be different. If the amplification is zero, then the input impedance of the amplifier consists of the sum $(R_s + Z_s + R_1)$. As A is increased from zero to unity, the voltage developed across the output terminals of the amplifier will be of such a direction that it will aid the applied voltage and the current will increase. When $A = 1$, the input voltage just equals the output voltage, and the voltage drop across the entire arrangement will be zero, which corresponds to zero input impedance. The current at this point will be limited entirely by the internal impedance of the source of voltage e.

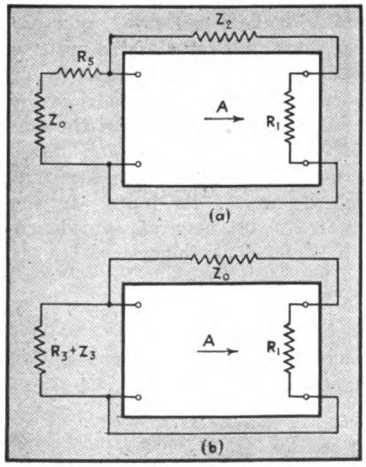

FIG. 5—Rearrangement of Fig. 1 and 2 shows that both shunt and series negative impedance are obtained from the same basic circuit. (a) corresponds to Fig. 1, (b) to Fig. 2

If A is larger than 1, there will be a negative drop across the amplifier and its input impedance will be negative as defined by Eq. (6) and (7). If A is increased to the point where the current is so large that it supplies all the losses in its path, instability will be reached. As is shown in the special case illustrated in Fig. 4, the current for a constant voltage will continuously increase, from a value determined by $(R_s + R_1 + Z_s)$ when $A = 0$ to infinity when all the losses are supplied by the amplifier.

As is clearly evident from these considerations and Fig. 4, the negative impedance will be stable and finite as long as its value is smaller in magnitude than the impedance in series with which it is connected. Thus, in the stable region of operation, the series combination of positive and negative impedance is positive, and for this reason, this type of a negative impedance is called a series negative impedance.

Negative-Impedance Limits

From this discussion it is evident that across a given positive resistance any value of negative resistance may be placed, from zero to infinity, and providing the negative resistance is of the right kind (shunt or series), a stable result will be obtained. It is plain that the ordinary concept of resistance is incomplete; a prediction regarding the behavior of the combination of positive and negative impedances cannot be made without complete information regarding the method used to supply the negative element. A more complete, but not any more rigorous, discussion will be found in the literature.[3, 4, 6]

In Fig. 1 and 2 resistances R_s and R_s are not essential parts of the negative impedances and Eq. (3) and (6) show that negative impedances will result whether these two resistances are present or not. However, due to the finite magnitude of the output impedance of the amplifier the negative impedance obtained by means of the amplifier alone will contain a term which is due to the output impedance of the amplifier. By placing proper positive resistances in series with the negative impedance the resistive component of this term will be can-

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celled and a pure negative impedance can be obtained. In the case of an ideal amplifier this cancellation can always be done; in the discussion which follows, it will be invariably assumed to have been done. Errors due to this assumption in the case of an actual amplifier will be discussed and analysed in Part II.

Stability

Before launching into the discussion itself, the particular sense in which the terms are used will be defined.

Conventional technical terminology is often confusing, the word stability having more than one meaning. In this paper there are discussed two kinds of stability and, although somewhat related, their meanings are different.

Operation of an amplifier is generally termed stable if introduction of an infinitesimal voltage anywhere in the amplifier will result in a transient which will decrease with time. If, on the other hand, the introduction of such voltage will produce currents which will increase indefinitely with time (or until limited by saturation of some element), operation of the amplifier is said to be unstable but in this paper such a result will be termed oscillation.

The second type of stability will be defined by the word stability itself, and will refer to the amount that the negative impedance can change due to a small variation in amplification of the amplifier, as for example by power supply voltage variation.

Conditions for Oscillation

Because positive feedback around an amplifier is used to produce negative impedance, it is to be expected that oscillation will occur for some conditions; in fact the previous qualitative examination of the effect of amplifier gain indicated, that for large amplification, oscillation does take place; therefore a more rigorous analysis of the conditions for oscillation will be made.

Figures 5(a) and 5(b) are rearranged forms of schematic circuits shown in Fig. 1 and 2 in which Z_0 is the internal impedance of the source e. From these it is seen that the actual circuits which develop negative impedances are identical in character, the difference being merely in the two points across which the desired negative impedance is developed.

On the basis of the criterion given by Nyquist' the possibility of oscillation may be determined by considering the circuits as positive-feedback circuits in which the impedance Z_0 is the impedance which is actually used across the terminals of the negative impedance. In general, it is impossible to predict whether oscillation will or will not occur except by applying Nyquist's criterion. In simple cases, however, it is possible to examine the circuits in the following manner.

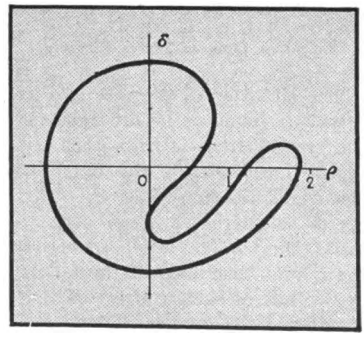

FIG. 6—Oscillations can not occur unless point (1, 0) of the Nyquist diagram is enclosed by the feedback-factor curve

The oscillations cannot occur unless there is a value of the positive feedback factor αA equal to or greater than unity, where A is the amplification parameter of the amplifier and α is the fraction of the output voltage of the amplifier that appears across its input. In the case of shunt negative impedance, α is defined as follows

$$\alpha = \frac{R_s + Z_0}{Z_0 + R_s + Z_s} \qquad (8)$$

And in the case of series negative impedance

$$\alpha = \frac{R_s + Z_s}{Z_0 + R_s + Z_s} \qquad (9)$$

The positive-feedback factor αA is a complex number and is a function of frequency in a way which is determined by the type of amplifier used and the character of the feedback network. It can be divided into a real and an imaginary part $\alpha A = \rho + j\delta$.

A not sufficient but a necessary condition for oscillation is that $\delta = 0$. There may be several frequencies at which this condition is satisfied, say, at $f_1, f_2, f_3, \ldots f_n$. If the real part of αA at any one of these frequencies exceeds unity, then oscillations will exist. Hence, the condition for oscillation may be stated as

$$\rho(f_1, f_2, f_3 \ldots f_n) \gtrless 1 \qquad \delta = 0$$

The one possible but unusual and seldom met exception to this rule may occur as is shown in Fig. 6 where, according to Nyquist's criterion, oscillations cannot occur. On the other hand, if the smallest value of $\rho(f_1, f_2, f_3 \ldots f_n)$ is greater than unity, then re-entrant curves around the point ($\rho = 1, \delta = 0$) are impossible and oscillations will necessarily exist. This is by far the most usual case.

If, for instance, the source impedance Z_0 is zero in the case of the series negative impedance, then according to Eq (9) $\alpha = 1$ and $\alpha A = 1$. In the ideal amplifier (or in a practical one at the point where the phase shift is zero) A is a real constant so that $\delta = 0$. If A is greater than unity, then oscillations must occur. In the case of a shunt negative impedance, if the source impedance Z_0 is made infinite, then $\alpha A = 1$ and oscillations must occur. This is seen to be in agreement with the physical interpretation of the negative impedance previously described.

Stabilization of Negative Impedances

Behavior of the negative impedance obtained in the manner illustrated in Fig. 1 and 2 depends only upon two factors, namely, the amplifier and the positive impedance. The positive impedances Z_s and Z_s are ordinary impedances constructed from resistors, inductors, and capacitors. The resultant negative impedance will obviously possess all the characteristics of these elements such as impedance change with temperature or with the amount of current or voltage applied to them. But in addition to these, the negative impedance is

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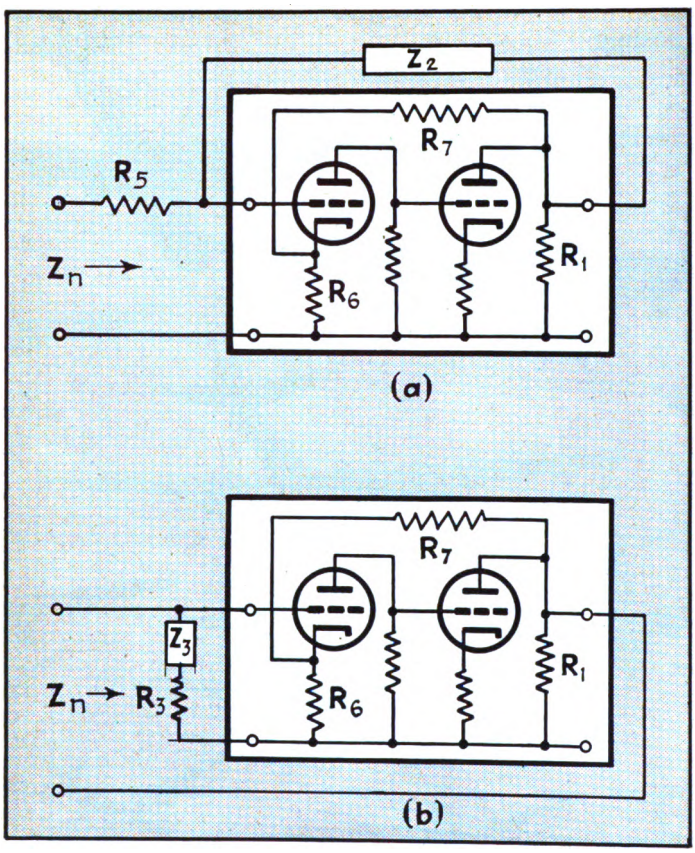

FIG. 7—Feedback to stabilize amplifiers used to produce negative impedance is produced by R_5 and R_7 at (a) for shunt and at (b) for series negative impedance

also dependent upon the gain of the amplifier used to supply that negative impedance.

In ordinary amplifiers the amplification often changes because of voltage fluctuations of the power supplies. Slow changes in tube characteristics and aging of the components of the amplifier also produce slow variations in the gain of the amplifier, and these, of course, will change the magnitude of the negative impedances. However, all of these factors may be greatly reduced by sufficient negative feedback within the amplifier itself. As will be shown later, the characteristics of the negative impedance can be easily made dependent, not upon the properties of the amplifier that supplies it, but upon the variations of the positive impedances Z_2 and Z_3 in the way mentioned previously.

The stabilization of the amplifier that supplies the negative impedances is well known and does not need to be fully described here.[1, 8, 9, 10] Important properties of stabilized amplifiers of particular interest in connection with the negative impedances will be taken up in Part II. Simplified diagrams of possible ways in which feedback can be applied to amplifiers supplying negative impedances are shown in Fig. 7(a) and 7(b).

Effect of Negative Feedback

The amplifier shown in both cases is a two-stage amplifier with all sources of power and filter network omitted for the sake of simplicity. A two-stage amplifier is necessary because the output and the input must be of the same relative polarity. A fraction β where $\beta = R_6/(R_6 + R_7)$ of the output voltage of the amplifier is returned to its input in such a manner that negative feedback is developed in the amplifier and its gain is stabilized by the factor $A\beta$, where A is the amplification of the amplifier with all feedback networks omitted. Except for the introduction of negative feedback, these circuits will be found to be the same as the schematic representations shown in Fig. 1 and 2.

The negative impedance developed by the amplifiers shown in Fig. 7 may be found in the same manner as in Eq. (4) and (7) if

A = amplification of the amplifier without negative feedback
β = fraction of the output voltage returned to the input of the amplifier as negative feedback
G = gain with negative feedback

$$G = A/(1 - A\beta) \tag{10}$$

and R_5 and R_6 so adjusted that

$$R_5 = R_1/(G - 1) \tag{11}$$

$$R_3 = R_1/(G - 1) \tag{12}$$

then, the shunt negative impedance will be given by

$$Z_n = Z_2/(1 - G) \tag{13}$$

and the series negative impedance by

$$Z_n = Z_3\,(1 - G) \tag{14}$$

In the material that is to follow, it will be assumed that R_3 and R_5 are so adjusted that Eq. (11) and (12) hold and Eq. (13) and (14) will be used with this implication in mind. For the sake of simplicity, all diagrams shown from this point on will not show resistances R_3 and R_5, although their presence is implied in all cases where a pure negative impedance is desired.

Stability of Negative Impedances

At first sight it may be thought that simultaneous application of positive and negative feedback in the same amplifier will simply produce cancellation, and if equal feedback factors are used the result would be the same as if no feedback were used at all. However, this is not so, as will become apparent as the discussion progresses.

As was seen in the above derivations and discussions, circuits shown in Fig. 1 and 2 produce negative impedances. By application of negative feedback internally to the amplifier its gain may be stabilized in the conventional manner. The extent to which the negative feedback stabilizes the negative imped-

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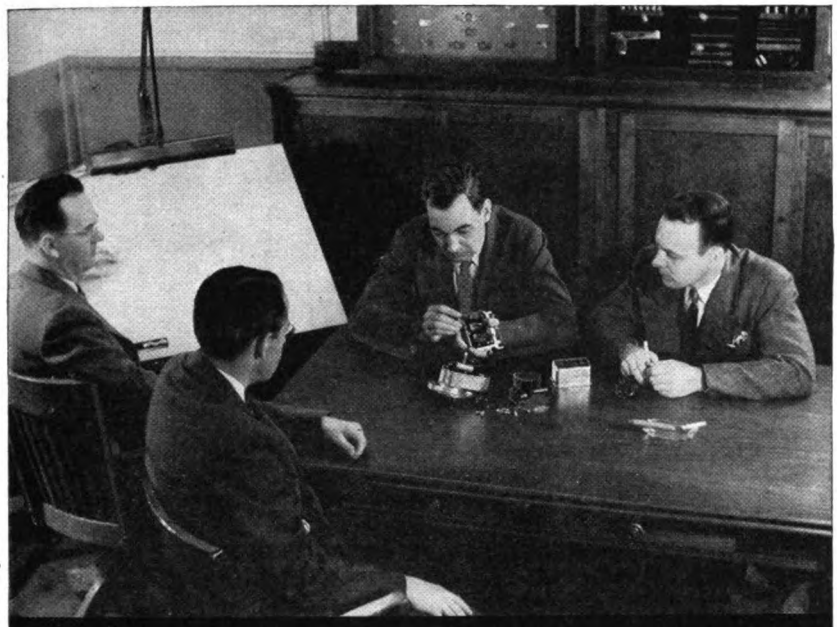

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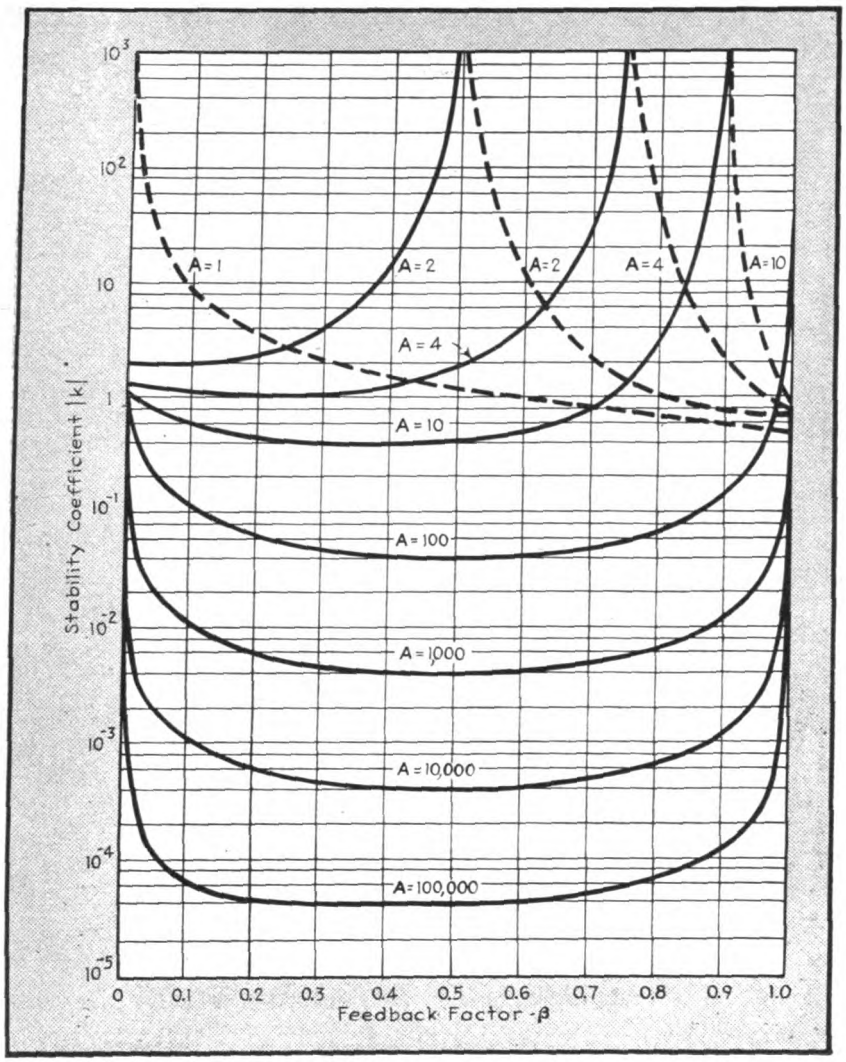

FIG. 8—Stability coefficient as a function of amplification and negative feedback shows regions in which best stability of negative impedance can be obtained

ances will now be determined quantitatively.

Stability of a negative impedance may be defined as the fractional change in negative impedance produced by a small change in gain of the amplifier which supplies that negative impedance. Stated algebraically $\partial Z_n/Z_n = k\partial A/A$ where A is the gain of the amplifier, ∂A is a small change in the gain, ∂Z_n is the change in the negative impedance, and k is a coefficient of stability, obviously dependent upon the amount of negative feedback utilized in the amplifier.

The coefficient of stability k describes to what extent negative impedance is affected by small changes in the propagation parameter of the amplifier. The ideal case would be obtained if k were zero, i.e., when a small change in the propagation parameter of the amplifier would produce no change in negative impedance.

As will be seen presently, stability of the shunt and series negative impendance is different, and the analyses will be divided into separate parts.

Stability of Shunt Negative Impedance

The shunt negative impedance is dependent upon the gain of the amplifier in the way expressed by Eq. (13). Substituting the value of G given by Eq. (10) in Eq. (13) one obtains for negative impedance the expression

$$Z_n = Z_2 \frac{1 - A\beta}{1 - A\beta - A} \qquad (15)$$

The stability coefficient may be obtained from this expression by differentiating with respect to A giving change in Z_n to change in A

$$\frac{\partial Z_n}{\partial A} = Z_2 \frac{\beta(A\beta + A - 1) + (1 - A\beta)(\beta + 1)}{(1 - A\beta - A)^2}$$

$$= Z_2 \frac{1}{(1 - A\beta - A)^2}$$

and therefore

$$\frac{\partial Z_n}{Z_n} = \frac{\partial A}{(1 - A\beta - A)(1 - A\beta)}$$

From which, the stability coefficient may be recognized as

$$k = \frac{A}{(1 - A\beta - A)(1 - A\beta)}$$

This important relation states that shunt negative impedance is stabilized by a factor which does not contain Z_n and hence, the stability of shunt negative impedance is independent of its magnitude.

Investigation of the property of the stability coefficient shows that there is an optimum value of β for any given value of A. The best value of β may be obtained by maximizing Eq. (18) with respect to β, as follows

$$\frac{\partial k}{\partial \beta} = \frac{A[(1 - A\beta - A)A + (1 - A\beta)A]}{(1 - A\beta - A)^2 (1 - A\beta)^2} = 0$$

Solving this for β

$$\beta_{opt} = \tfrac{1}{2}\left(\frac{2}{A} - 1\right)$$

from which the optimum value of β for any given value of A may be obtained. The stability coefficient at β_{opt} is

$$k_{opt} = -4/A$$

Another critical point occurs when the denominator of Eq. (1) becomes zero, i.e., when $(1 - A\beta - A) = 0$. This is the case when

$$\beta = (1 - A)/A$$

At this value of β the stability coefficient is infinite and a small change in gain would produce an infinite change in the negative impedance. However, at this value of β the gain of the amplifier is unity

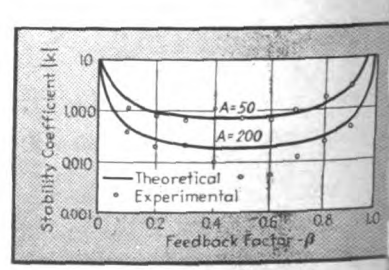

FIG. 9—Experimental determination of stability verifies the theoretical prediction

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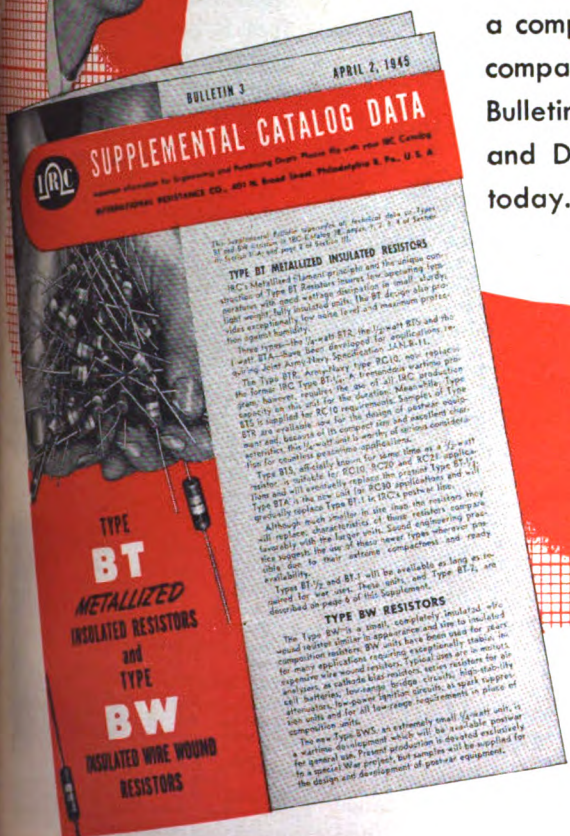

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and the negative impedance is infinite and obviously this critical point is of no importance.

Stability Calculations

Figures 8 and 9 show Eq. (18) in graphical form as a function of A and β. From Fig. 8 it is seen that the larger the propagation constant of the amplifier, the better the stability of the shunt negative impedance. If A is very large, then $\beta = -0.5$ gives the best k, but there is little improvement beyond $\beta > 0.1$ and in all practical cases this is the most satisfactory value due to the difficulty of obtaining a high value of A and a higher value of β than 0.1 due to the shunting effects of the β network.

With present day tubes it is easy to obtain an amplification of 10,000. If enough negative feedback in the amplifier is used to make $\beta = -0.1$, then, according to Eq. (18) or Fig. 8, the stability coefficient is nearly 10^{-3}.

A test of a simple amplifier has shown that a 20 percent change in the supply voltage of a typical amplifier produced an 8 percent change in amplification. Hence, the change in the negative impedance supplied by this amplifier would be in the neighborhood of eight parts in 100,000. This stability is better than that encountered with ordinary circuit elements in cases where no temperature compensation is provided.

Stability of Series Negative Impedance

Effects of small changes in amplification of the amplifier which supplies the series negative impedance may be obtained in a similar manner. Series negative impedance is dependent upon the gain of the amplifier as given by Eq. (12) and (14). Combining this with the Eq. (10) which takes into account the negative feedback in the amplifier

$$Z_n = Z_s' \left(\frac{1 - A\beta - A}{1 - A\beta} \right) + R_1 \qquad (23)$$

where $Z_s' = Z_s + R_s$

From this, the stability coefficient may be obtained by differentiation

$$\frac{\partial Z_n}{Z_n} = \frac{-\partial A}{(1 - A\beta)\{(1 - A\beta[(R_1/Z_s') + 1] - A\}} \qquad (24)$$

The stability coefficient is

$$k = \frac{-A}{(1 - A\beta)\{(1 - A\beta)[(R_1/Z_s') + 1] - A\}} \qquad (25)$$

This relation is different from the corresponding one for the shunt negative impedance because it involves the terms Z_s', which means that the stability of a series negative impedance depends upon the magnitude of the negative impedance developed by the amplifier. A physical interpretation of this dependence may be seen by examining two boundary cases.

If the output impedance of the amplifier $R_1 << Z_s'$, then the stability coefficient becomes very much the same as the one in the shunt negative impedance. If $Z_s' = R_s = R_1/(G\text{-}1)$, the second bracket in the denominator of Eq. (25) reduces to zero. In this case, the stability coefficient becomes infinite. This latter case is of not much practical importance, for it corresponds to zero series negative impedance offered by the amplifier. In a practical amplifier, the output impedance of the amplifier can be made small, and for any given value of the negative impedance, the stability coefficient may be made as small as is desired by increasing A sufficiently. Rewriting Eq. (25) shows this more clearly

$$k = \frac{-1}{(1 - A\beta)[1 - (1 - A\beta)/A][(R_s/Z_s') - 1]} \qquad (26)$$

If A is made very large, then

$$k \approx \frac{1}{A\beta[1 + \beta][(R_s/Z_s') - 1]} \qquad (27)$$

and the stability can be made as good as desired by making A large enough.

For any given value of R_1/R_s' and A there is a best value of β. This critical value may be obtained by maximizing k as given by Eq. (25) with respect to β. This leads to the result.

$$\beta_{opt} = -\tfrac{1}{2}(1 - 4R_s/AZ_s') \qquad (28)$$

This again differs from the best value of β in the shunt negative impedance as given by Eq. (22) because Eq. (28) involves the factor R_s/Z_s', i.e., it depends upon the value of the negative impedance developed by the amplifier. The stability coefficient for the series negative impedance at the best value of β is obtained by combining Eq. (28) with Eq. (25) or (26). This gives

$$k_{opt} = -\frac{4}{A} \frac{1}{[(2R_s/Z_s')^2 - 1][(R_s/Z_s') - 1]} \qquad (29)$$

which differs from the optimum value of the stability coefficient in the case of shunt negative impedance in the same general manner discussed above in connection with Eqs. (25) to (28).

Most Stable Condition

It is interesting to notice that if $R_s/Z_s' << 1$, then the optimum value of β in the case of the series negative impendance is $-\frac{1}{2}$. This is also true (exactly so, however) in the case of the shunt negative impendance. Remembering the fact that the gain of the negative-feedback amplifier approximates $-1/\beta$ it is seen that if the optimum value of feedback is used for best stability, the gain of the amplifier supplying negative impedance is just equal to 2. Hence, from Eq. (13) and (14) it is seen that the negative impedances developed by the amplifier in the two possible manners are

shunt type $Z_n = -Z_2$
series type $Z_n = -Z_3$

In other words, if the most stable operation of the negative impedance is desired, the value of the negative impedances obtained are merely the negative values of the positive impedances Z_3 and Z_2.

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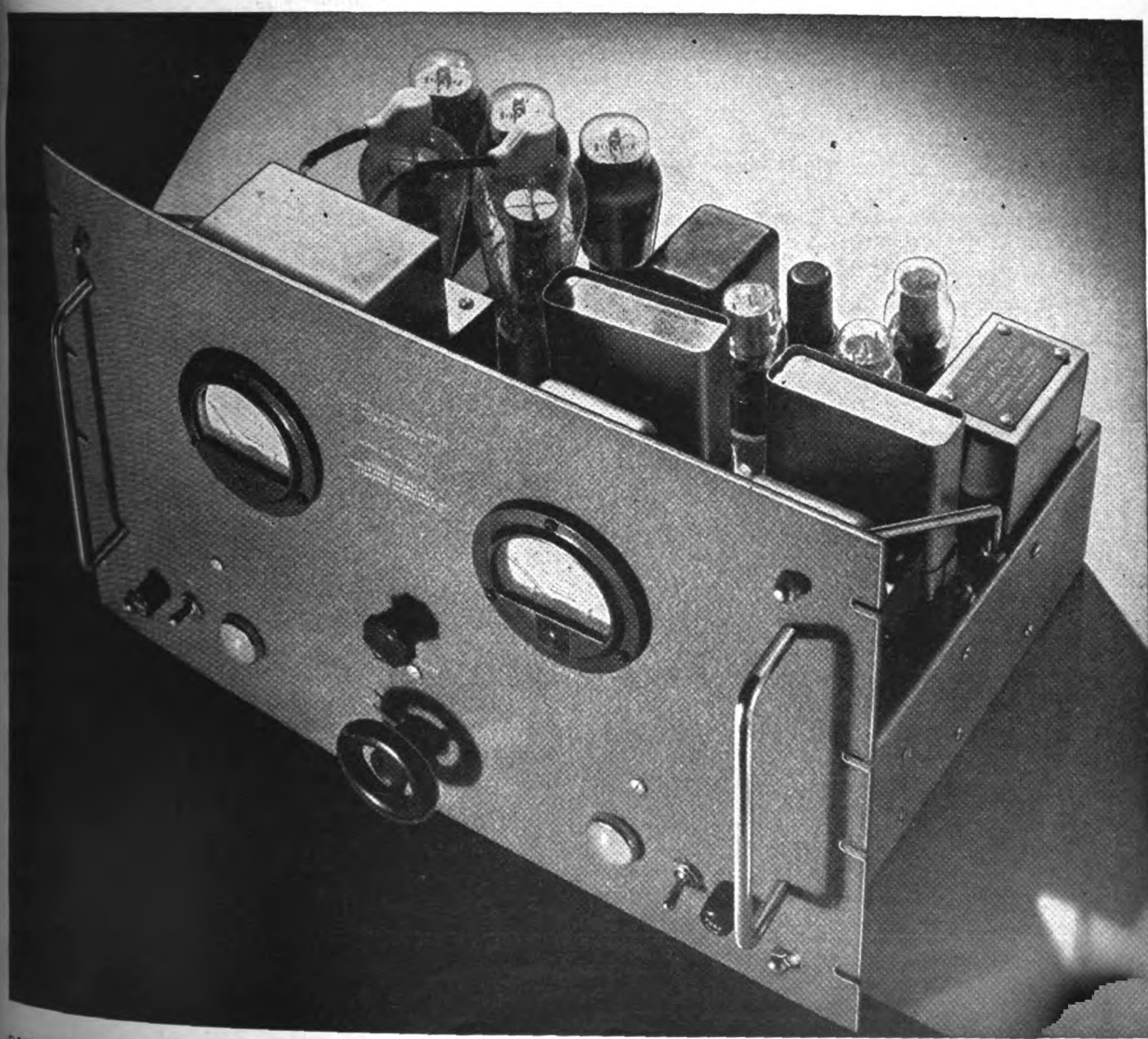

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Phototubes for Railroad Operations

AT THE NEW DIESEL locomotive maintenance shop of the Erie Railroad, phototubes are used for two purposes—to open electrically operated overhead doors and for drying and elevating sand into overhead storage tanks.

The door control is actuated by the beam from the headlight of the approaching locomotive while it is still some distance away. This allows plenty of time for the ponderous doors to open and permit the locomotive to enter the shop without a preliminary stop.

A sun visor is provided over each phototube to prevent the sun from activating it. Pushbuttons inside the building operate the door-closing mechanism after the locomotive has entered.

The sand for the sand boxes of the 5400-hp four-unit diesel freight locomotives is dried by steam coils over a drum, into which the sand flows by gravity as it dries. Into the side of this drum is welded a pipe, so shaped that it permits sand to spill over when the drum becomes full. About half-way down the interior of this pipe is welded a box containing a glass window on each side. Through these windows a beam of light is passed to a phototube.

When the drum becomes full of sand, the surplus flows over into the pipe and interrupts the beam of light. Compressed air is immediately turned on, closing the inlet to the drum and applying pressure to the top of the sand. The sand is blown into elevated bins, where it is ready for use in servicing the locomotives.

When the drum has been emptied, the windows of the box inside the pipe are again cleared and the lightbeam pases through them to reach the phototube. This turns off the compressed air, re-opens the inlet to the drum, and allows it to fill again—ready for the next operation. This mechanism has proven much more dependable than any previous combination of springs, switches, or other mechanical action.

When diesel locomotives approach this Erie maintenance shop, the headlamp shines into a phototube which actuates a door opener and eliminates a preliminary stop while trainmen open the door

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THE PRINCIPLE of operation of an electronic gas gage for bombing planes, recently announced by Minneapolis-Honeywell, can well be applied to a large number of manufacturing operations, in refineries, large storage vats, and even as a means of measuring the moisture content of wheat and other materials.

The illustration shows the installation of the gas gage units in a typical four-engined airplane. In the gas tanks are mounted capacitance units which connect to an electronic amplifier and meter mounted in the fuselage. Each capacitance unit consists of a piece of tubing which contains two smaller pipes inside to form the elements of an electrical capacitor. Gasoline can flow inside the tubing and between the two inside pipes. The minute current flow from one pipe through the gasoline to the other pipe shows the electrical capacitance of the gasoline. This changes with the height of the liquid within the tank unit and is measured electronically by the amplifier. Actuated by the amplifier, an indicating dial on the plane's instrument panel shows the contents of the tank in gallons.

Unusual Conditions

The problem of determining fuel supplies is not an easy one for plane crews. Gasoline actually shrinks in volume with a drop in temperature and, from ground level to 25,000 feet, this shrinkage frequently reaches 10 percent. In addition, the level of gasoline constantly changes with the roll (or tipping) axis of the plane, giving false readings on conventional gages of as much as 20 percent error. This degree of error, when coupled with shrinkage and other

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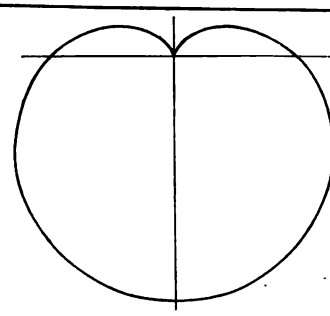
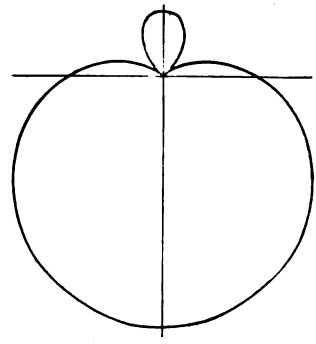
"Cardioid" means heart-shaped. It describes the pickup pattern of a microphone as illustrated in this diagram. Unwanted sounds approaching from the rear are cancelled out and the pickup of random noise energy is reduced by 66%. The actual front to back ratio of reproduction of random sound energy is 7 to 1.



.. This is Super-Cardioid

"Super-Cardioid" also describes a pickup pattern and is a further improvement in directional microphones. The Super-Cardioid has a wide front-side pickup angle with greater exclusion of sounds arriving from the sides and the rear. The front to back random sound ratio is 14 to 1 which makes it twice as unidirectional as the "Cardioid." A 73% decrease in the pickup of random noise energy is accomplished.



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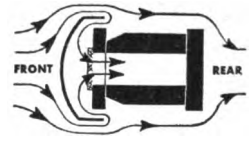
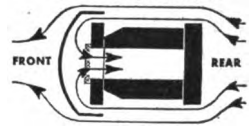
"Uniphase" describes the principle by which directional pickup is accomplished in a single Microphone unit. This is a patented Shure development and makes possible a single unit "Super-Cardioid" Directional Microphone eliminating the necessity of employing two microphone units in one case—it gives greater uniformity in production, greater ruggedness, lower cost for comparable quality and more uniform vertical pickup pattern.



Sounds entering from front.



Sounds entering from rear.

.. This is the result

The SHURE Super-Cardioid

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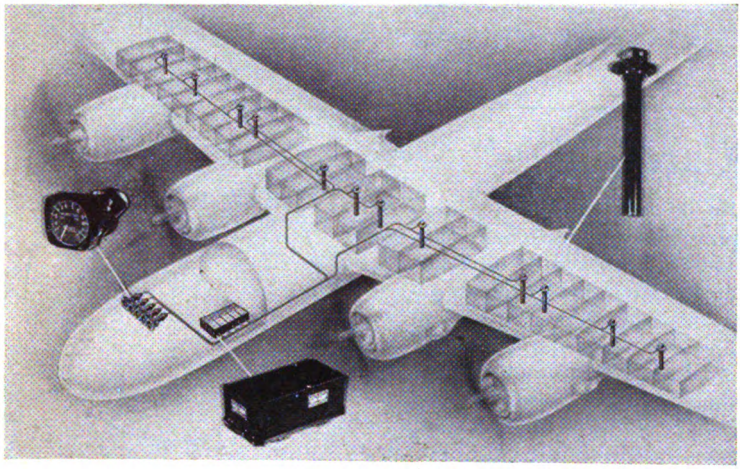
factors, can lead a pilot to believe that he has hundreds of gallons more (or less) available than are actually in the tank.

The needles of float-type fuel gages fluctuate constantly. This is sometimes further amplified because at the low pressures encountered at high altitudes, the fuel boils, causing a foam to form—similar to a bubble bath—on the surface of the gasoline and the float rides on top of the bubbles, thus indicating a still greater supply.

Developed at the request of the Air Technical Service Command, Wright Field, Dayton, Ohio, the new device is accurate within five percent under extreme conditions of temperature, altitude and plane attitude. This compares with at least a 15 percent error in the best of all existing means of aircraft fuel measurement. With no moving parts, bellows, gears, cams or levers to get out of calibration, the liquid level indicator weighs about 16 pounds, slightly more than present fuel measuring systems.

The unit now being manufactured is actually the second of two designs developed by Minneapolis-Honeywell. Both of these developed from a basic electronic circuit used by the company in an ice indicator which measures ice forming on wing and plane surfaces and turns on the deicer pumps before weight and bulk of the ice become dangerous.



Gas-gage installations in a typical four-engined plane. The liquid level unit, shown at upper right, makes use of electrical capacitance and may find extensive use in industrial applications. Accuracy is within five percent as against fifteen percent for other devices used in fuel measurement

Elongation Recorder for Materials Testing

By JENS SIVERTSEN
Electrical Engineer
Tinius Olsen Testing Machine Co.
Philadelphia, Pa.

MILITARY NEEDS—in aviation, ordnance, marine equipment, and industrial mechanisms—have forced greater tensile strengths, higher working limits and lower safety factors for many classes of materials.

In testing most materials, the stress-strain diagram is recognized as the fundamental characteristic and helps to find modulus of elasticity, hysteresis, elastic deformation, proportional limit, yield strength, and proof stress. Essentially the Olsen high magnification recording unit is a specially designed extensometer which transmits the characteristics of the material under test by electronic means to a letter-size chart applied to the recorder drum.

Degree of Strain

The strain of most rigid materials in the elastic straight-line region is very little. In a piece of plain carbon, cold C. R. steel it may be 0.001-0.002 in./per inch length of material, corresponding to a load at 30,000-60,000 lb/per square inch; for cast iron it may be as little as 0.00025-0.0005 in. and for high grade heat-treated

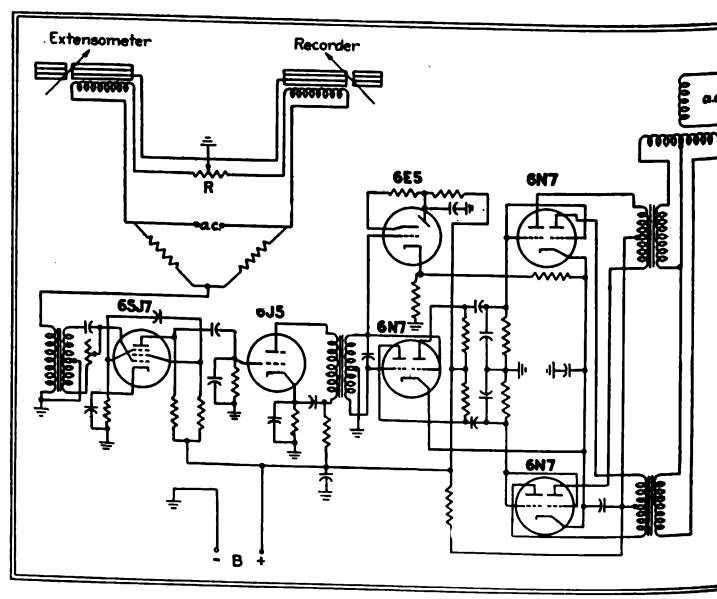


Fig. 1—Electronic amplifier and Wheatstone bridge arrangement used in the materials tester. The motor speed is variable and reversible depending on the signal from the bridge circuit

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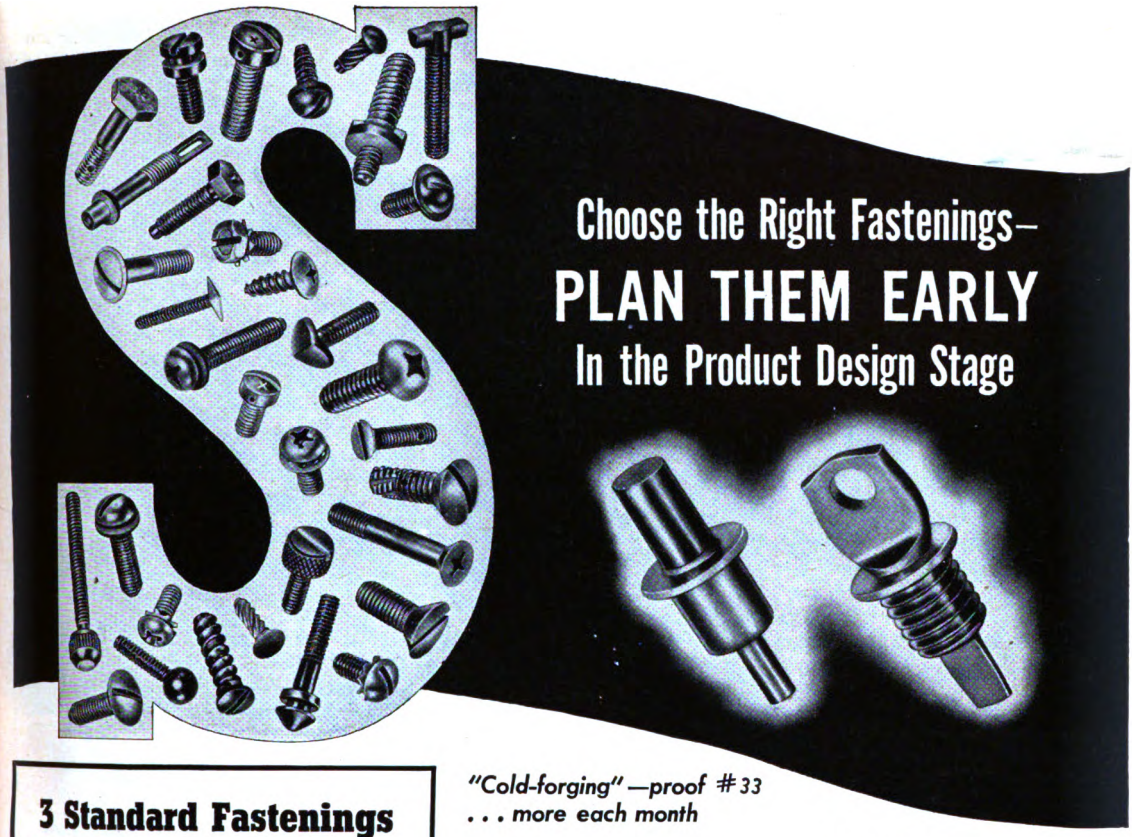

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The degree of perfection you will obtain on that vital fast assembly job may very well depend on the fastenings chosen for your product. That's why it is important to play safe by making your precise choice early in the design stage. Remember—no assembled product can be better than its fastenings.

Whether your need be a featured standard fastening or a part especially designed to meet your specific requirements—Scovill can help you. Our broad experience in fastenings and our demonstrated ability in special design make Scovill your logical choice.

The special purpose item featured above (in intermediate and finished stages) is one of many examples of our ingenuity in special design and cold-forging. Our special processing of this part, too, meant substantial savings in money—materials—motions.

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tool steel, it may be as much as .005 in.

Instruments to measure and record these small dimensional changes were made 50 years ago. They used long specimens which were cumbersome to use and the operator had to be an expert. However, it is remarkable how good the results were with such equipment.

The recorder was ready and a few were in use before the war, by people who were not afraid of the radio tube in industry. Some organizations like Chrysler, Ford and the U.S.S.R. had quite a few of them. When the war came, the requirement for accuracy and volume of testing increased rapidly, and the work had to be done by operators with no previous training in this field. Since the recorder was simple to operate, anybody with normal intelligence could learn its use in a few hours.

Modern Design

The complete instrument comprises three units: the extensometer which is attached to the specimen, the electronic amplifier, and the recorder unit. In the extensometer is a magnet coil with an air gap between two iron cores. In the recorder unit is a similar coil and air gap. These two coils and their air gaps form an automatically balanced electrical circuit. The air gap in the extensometer is actuated by the elongation of the specimen. The air gap in the recording instrument is actuated by a micrometer screw which is rotated by the same motor which drives the recorder drum.

The electronic circuit is shown in Fig. 1. It consists of an a-c Wheatstone bridge, having a permanent base of two closely matched resistors. The other arms consist of one induction coil with a magnetic core and an air gap actuated by the strain in the test piece, and one identical inductor arranged in the recorder box actuated by a micrometer screw. The screw is synchronized by gears with the recording drum. The reversible motor drives the arrangement as a self-balancing assembly.

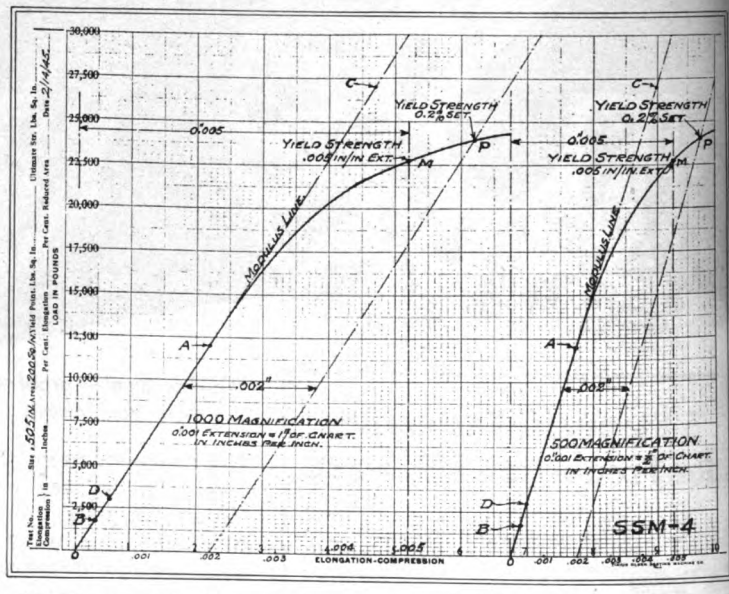
The output from the bridge energizes the primary of an input transformer. The secondary feeds the grid of a 6SJ7 pentode and the rest is a straightforward amplifier up to the two 6N7 output tubes. The plates of these tubes act in respect to the shading coils of the motors as variable impedances which for large signals may become negative. In this way, the motor becomes automatically reversible with change in phase of the incoming signal. The motor speed becomes variable over a large range and causes the recording drum to follow smoothly any strain of the specimen.

In spite of the very high sensitivity obtained, 0.000001 to 0.000005 in. elongation of the specimen, the amount of hunting is negligible. Some of the models are supplied with dynamic brake (aluminum disk in a magnetic field) while many are without this brake.

Balance

In view of the high sensitivity and the low signal, a 6E5 tube is used for balance adjustment. The arrangement is such that only inductance unbalance can affect the motor, as voltage caused by resistance unbalance is 90 deg. out of phase. A large resistance unbalance will, however, impair the sensitivity of the recorder. For this reason, the resistance balance can be adjusted by the small potentiometer R, shown on top in the bridge circuit, while observing the 6E5 balance indicator.

The 6E5 tube will also indicate whether the motor keeps the bridge circuit balanced at all times, which means that the recorder follows the elongation of the specimen minutely. Some small change in resistance may take place during



Typical stress-strain diagram (not retouched) made with a 30,000-lb. Olsen testing machine. Such recordings can be used to follow a material during cold working, heat treatment, and other operations, to provide a product with greater uniformity in shape, size and dimensions in service

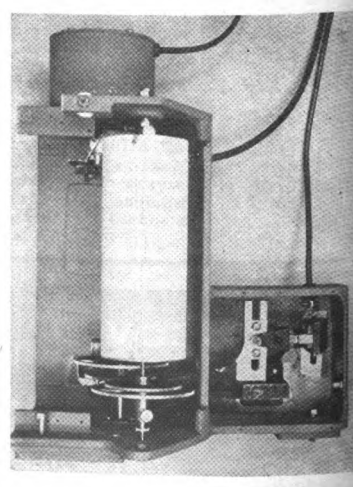


Fig. 2—Mechanical features of the recording unit

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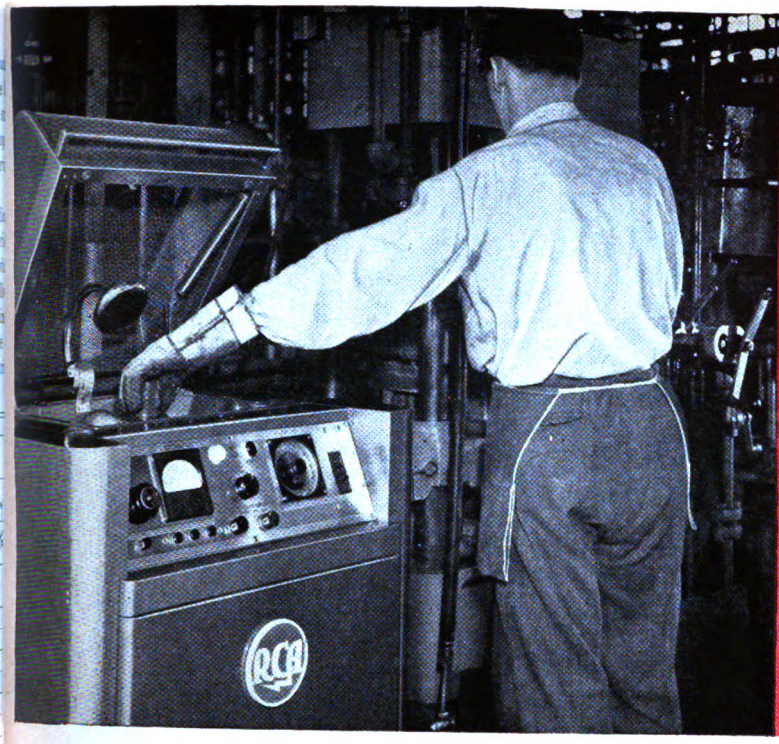

Cost of finished pieces was reduced 40% by this RCA preheating unit at Kellogg Switchboard and Supply Company.

Telephone "cradle" molded by Kellogg; with cold molding, 4 press cycles per hour—with electronic preheating, 6¼ cycles.

Kellogg Switchboard Reduces Cost 40% with Electronic Heat

Press Output Increased 56%; Molding Pressure Lowered; Warpage and Blistering Reduced with New RCA Automatic Plastics Preheater

Application: Kellogg Switchboard and Supply Company, Chicago, compression-molds a large quantity of telephone parts, including the "cradle" shown above. A four-cavity mold is used; each cavity takes 2 preforms weighing 1.75 ounces each. Material: Bakelite BM 2498. Molding Temperature, 320°F.

To step up production on this part, the Kellogg Switchboard and Supply Company installed RCA electronic preheating equipment. The complete charge of 8 preforms per mold is now preheated for 35 seconds to a uniform temperature of 220°F.

According to Mr. W. G. Cregeen, Assistant Shop Superintendent of the Kellogg Plant, electronic heating reduced the cost of finished pieces by 40%, and warpage and blistering, which were previously problems, are no longer troublesome.

	Cold Molding	Electronic Molding
Press Closing Time	1 min.	1 min.
Curing Time in Mold	5 min.	2½ min.
Press Cycles per Hour	4	6¼
Molding Pressure	125 psi	75 psi
Mold Damage		Less
Mold Life		Increased
Dimensional Tolerances and Stability		Better

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the first hour of a day's work, as the coils do not heat completely uniformly.

Figure 2 shows the mechanical parts of the recorder. The rack carrying the pen parallel to the axis of the recording drum has been removed. This pen provides the load ordinate for the chart and many types of testing machines give this automatically as an integral part of the weighing system of the machine.

A typical recording made with a 30,000-lb testing machine is shown. The specimen is a round steel bar 0.505 in. in diameter, which has a cross-section of 1/5 square inch. The testing machine gives load values in pounds; material constants are generally given in pounds per square inch. To get these, we divide by 1/5 or multiply by 5. For example, the proportional limit is at point A on the curve. The corresponding load reading from the chart is 12,000 lb. The proportional limit is, therefore, $12{,}000 \times 5 = 60{,}000$ lb per square inch.

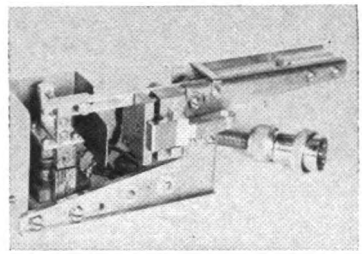


Fig. 3—One type of extensometer for the elongation tester

If we measure along the elongation axis on the original graph, we find the extension between origin and A equal to 2 in. Since the magnification is 1000 this represents 0.002 in. strain.

The modulus of elasticity is therefore:

$$E = \frac{60{,}000 \text{ lb per sq. in.}}{0.002 \text{ in. per inch}} = 30 \times 10^6 \text{ lb per sq. in.}$$

The right side of the chart shows the same curve with magnification of 500, which is used extensively in routine production testing, allowing a number of curves on the same chart. In view of the ease whereby the curve is obtained, the time may not be far off that all quality materials will be bought on the basis of a curve. Thus, a structural designer may now be able to use a safety factor of 10, 20, or 30 percent instead of 500 percent.

Pipe Gaskets Tested for Pressure

ELECTRONICS has come to the aid of engineers coping with one of the problems of pipeline equipment design—the uneven distribution of gasket pressure. Such a condition often leads to costly leaks. A new tester utilizes an audio howl as an aid to measuring pressures exerted by rubber gaskets in pipe couplings, clamps and repair sleeves. Called a Sealometer, it was developed by engineers of the Dresser Manufacturing Division of Dresser Industries, Inc.

In many types of pipe, a thick rubber gasket, compressed by bolting down iron clamps, is used to make a seal around the pipe. The unit pressure of this rubber gasket must exceed the pressure of the gas or liquid inside the line in order to prevent leakage. If there is any variation of the gasket pressure, the minimum pressure is the one which determines the safeness of the joint. It is very important to determine accurately the distribution of the pressure which the gaskets exert in order to properly design a successful joint.

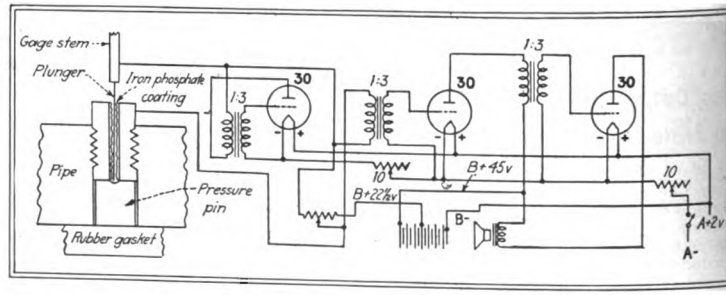
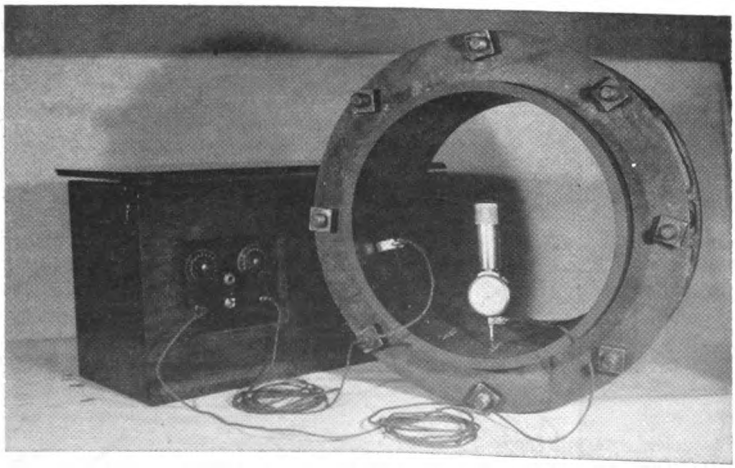


Fig. 1—Assembly details of the gage applied to a pipe gasket and the electronic circuit of the instrument for measuring gasket pressure in pipelines. When pressure is applied manually to the gage head, the plunger moves the pin away from contact with the shoulder of the threaded bushing



Complete setup of gage and audio oscillator-amplifier arranged to determine the variation of gasket pressure that occurs at different points of a pipeline joint

Most gasket tests have been based on the assumption that the pressure was uniformly distributed and that the unit pressure was equal to the total load divided by the area of the gasket. The problem of measuring the pressure which is exerted by an elastic solid such as rubber is much more com-

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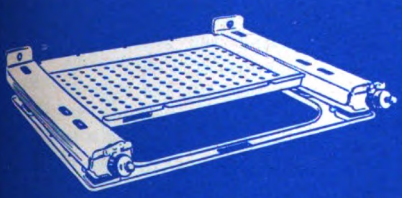

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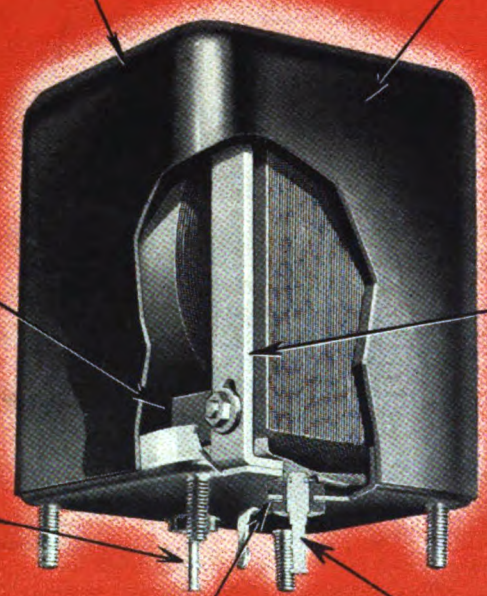

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plex than the measurement pressure. In the latter, t placement of fluid necessary tuate a gage does not usu fect the applied pressure. I uring rubber pressure, any ciable displacement of the will cause a considerable ch the pressure being measure introduces an error of u proportions.

Two methods existed for mining force or pressure wi minute displacement. One quartz crystal and the other sensitive carbon pile. Both large instruments and re could not be taken close enou gether to plot satisfactory pr distribution curves for the Also, frequent calibration is sary.

The principle of operation Sealometer involves measuri force exerted by the gasket the end of a "pressure pin" an area of exactly 1/100 of a Movement of the pin is limi a few millionths of an inch- reducing the displacement e a negligible value.

Test Procedure

For testing, each pressure accurately fitted in car reamed holes at desired poi the test specimen and adjust means of a special screw so tha end is flush with the surface tacting the gasket. A spec thus prepared has packing sur substantially the same as tho a joint in actual use, and th havior of the gasket is not al in any way. After the rubber in the test specimen is compre the pressure acting upon each is measured by applying an o ing force until a balance is obta and the few millionths of an displacement of the pin occurs. breaks the electronic circuit, ting up an audio howl. Figu shows the wiring circuit.

Three important factors i enced the design of the wiring cuit for the Sealometer. Freq opening and closing of the ci in measuring the pressures w foul the contacts unless a very s current were used. Also, the l tation of movement on the press

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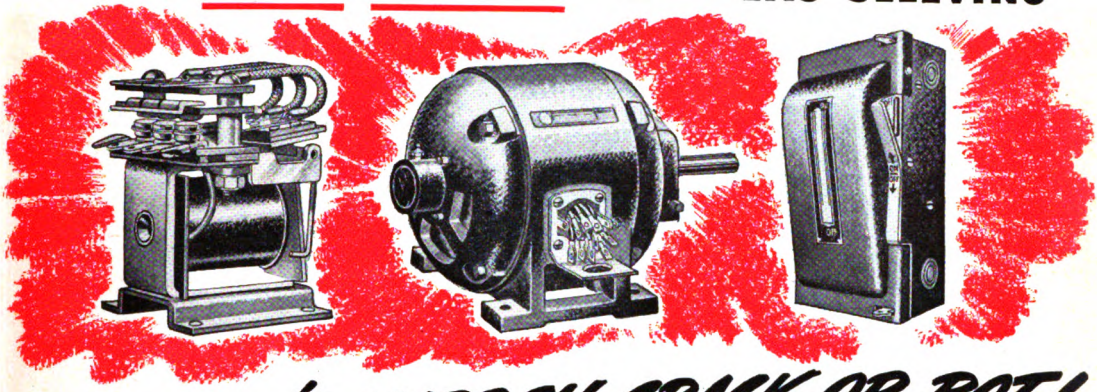

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pin in order to avoid error distortion of the rubber made it necessary to have a c that could not jump a gap of millionths of an inch. The lem of insulating the pressu so the current would flow pr also was involved.

One test lead of the unit co to the stem of the indicator The other test lead is attac the specimen being tested. the current travels throug shoulder of the adjusting scr way of the pressure pin t plunger of the gage stem.

Special Insulation

The circuit is broken when sure on the plunger moves th away from contact with shoulder of the adjusting s Difficulty was had with insul of the pin on all surfaces wh comes in contact with the re hole. A coating of iron phos finally was selected to be th sulating layer. While not a s ior insulation, it is sufficient t terrupt the slight current of circuit. This material over the tendency to cause the pi stick that other types of insul exhibited.

The opposing force applie the pressure pins is exerted ually. The stem of a dial indic gage is fitted with a special ne like plunger which can be inse through the hollow adjusting s to engage the pin. Mounted the stem is a handle housing a curately calibrated engine i cator spring that requires pound of pressure for each inch deflection. Pressure on handle is transmitted to the through the plunger, the press being measured by the spring recorded on the dial indicator. area of the pin is 0.01 inch each pound of pressure app manually represents 100 psi.

Advantages

Since the audio signal sou when the balanced pressure co tion is reached, the operator take readings without lifting eyes from the gage. This ma possible the reading and recordi of pressures at the rate of ab 150 per hour. Accuracy has b

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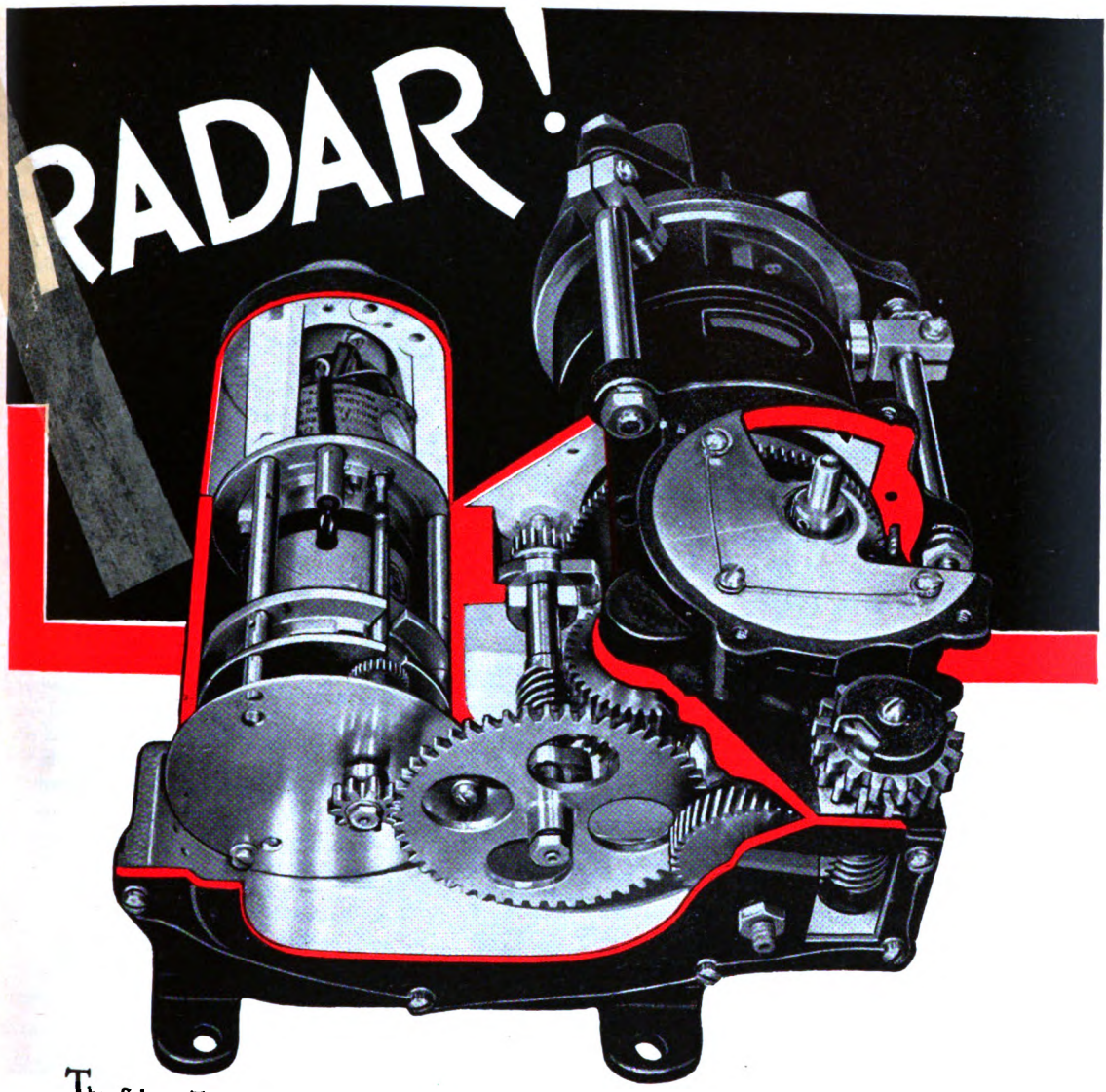

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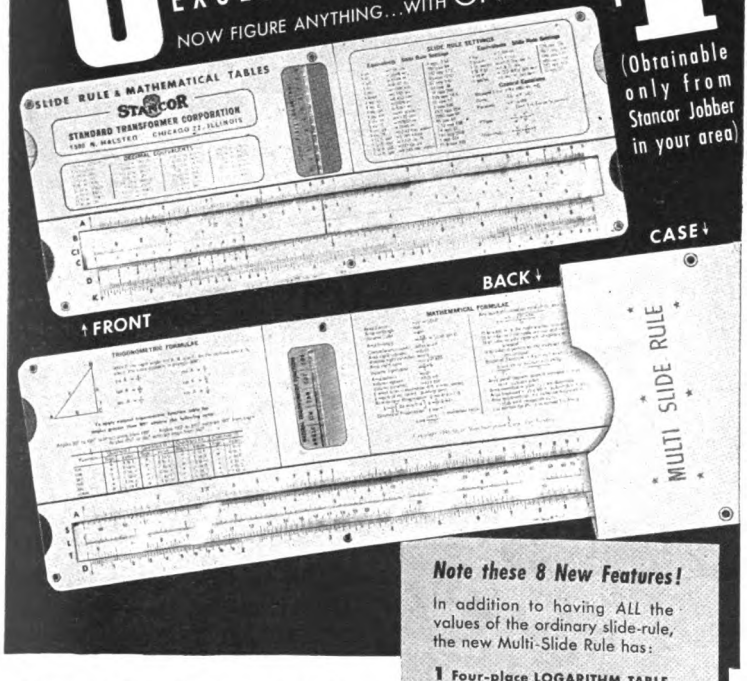

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checked at better than 98 percent correct by independent methods. Since the actual diameter of the pins is only 0.1128 inches, they can be spaced as closely as $\frac{1}{8}$-inch apart on the test specimen. Another advantage of the gage is that it permits pressure readings to be taken during assembly of a pipe joint as well as at any time thereafter. It is also possible to take readings while the joint is under line pressure. The gage is not affected by such factors as condition of the pipe or bloom on the gaskets, which seriously distort the results obtained by internal pressure tests.

In tests on one type of pipe joint, in spite of the fact that all bolts were tightened to exactly the same tension with a torque wrench, pressures ranging from 200 to 1000 pounds were recorded at various points around the gasket. On another, clamp pressures were found just above zero and dangerously close to the point at which leaks would occur. By using data compiled with the instrument, the pipe couplings were redesigned to equalize pressure throughout the gasket at a level well above minimum safety requirements.

• • •

Simplified Training for Assembly-Line Workers

By S. Frederick Auerbach

Engineer, Emerson Radio Television Corp.

Isometrics is the pictorial delineation of mechanical parts. More recently isometrics has been accepted and extensively used in the radio and aircraft industries for its clarity when used to show assembly of parts in exploded views.

During the war, many plants found that the personnel available for the assembly line was difficult and unsuited to train in blueprint reading. This condition necessitated an increased staff of key men and women to interpret and supervise the work. This type of assembly-line tutoring required many hours of training for supervisors and then, in turn, especially for workers who had to master the simple operations and commit them to memory. This was true even though the assemblies were broken down

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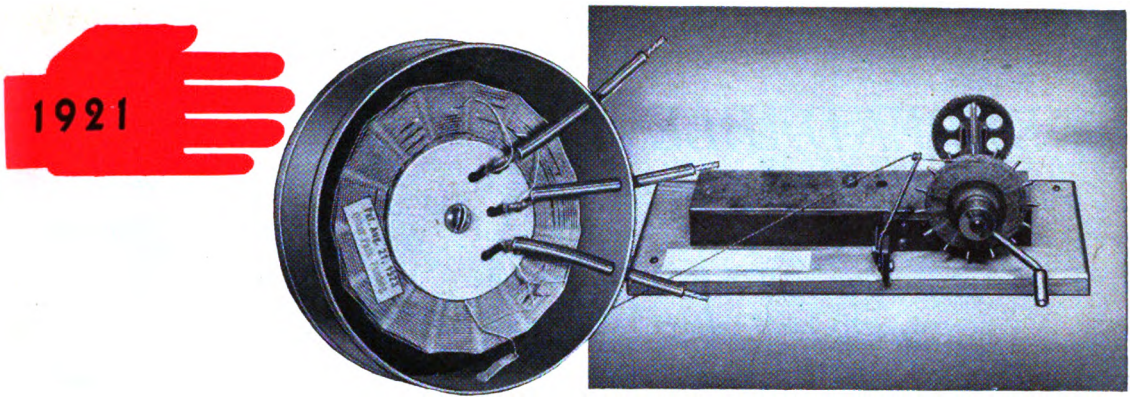

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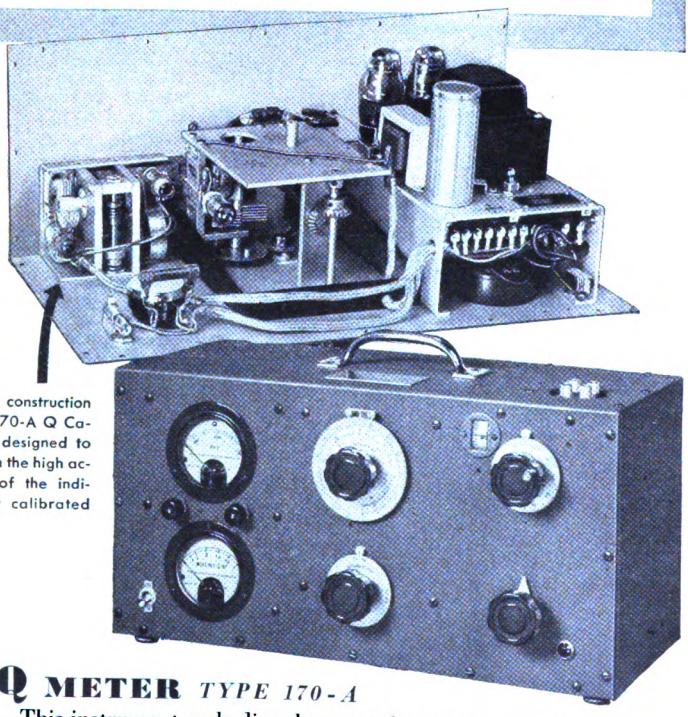

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into many smaller components and cycles than the job ordinarily warranted. It also required many more checkers and inspectors.

Advantages

It was soon discovered that isometrics could play an important part toward solving this problem. With such a drawing, all workers could easily recognize the parts required in the assembly when the subassemblies were properly prepared and broken down into cycles of fair size. It was simple to read with no explanation required or training necessary for the worker. And, more important than that, assembly was mastered more quickly by the individual worker so that a minimum amount of time was required for the breaking-in period. This has resulted in maximum production per worker. It has also eliminated a number of supervisors and, in the event a supervisor was

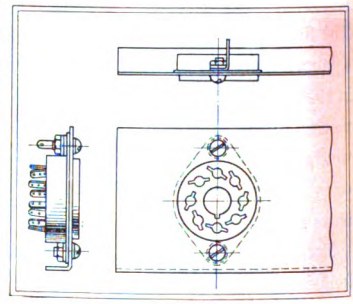
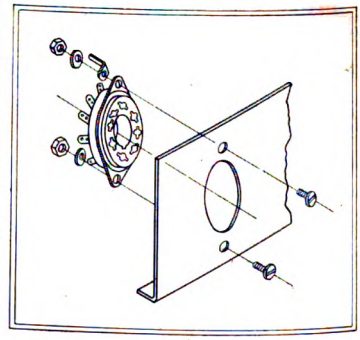


FIG. 1—An orthographic view of a socket and mounting requires three drawings to show the correct order of assembly

FIG. 2—Isometric view of the socket assembly shown in Fig. 1. Visualization of the order of operations is simplified for the assembly-line worker



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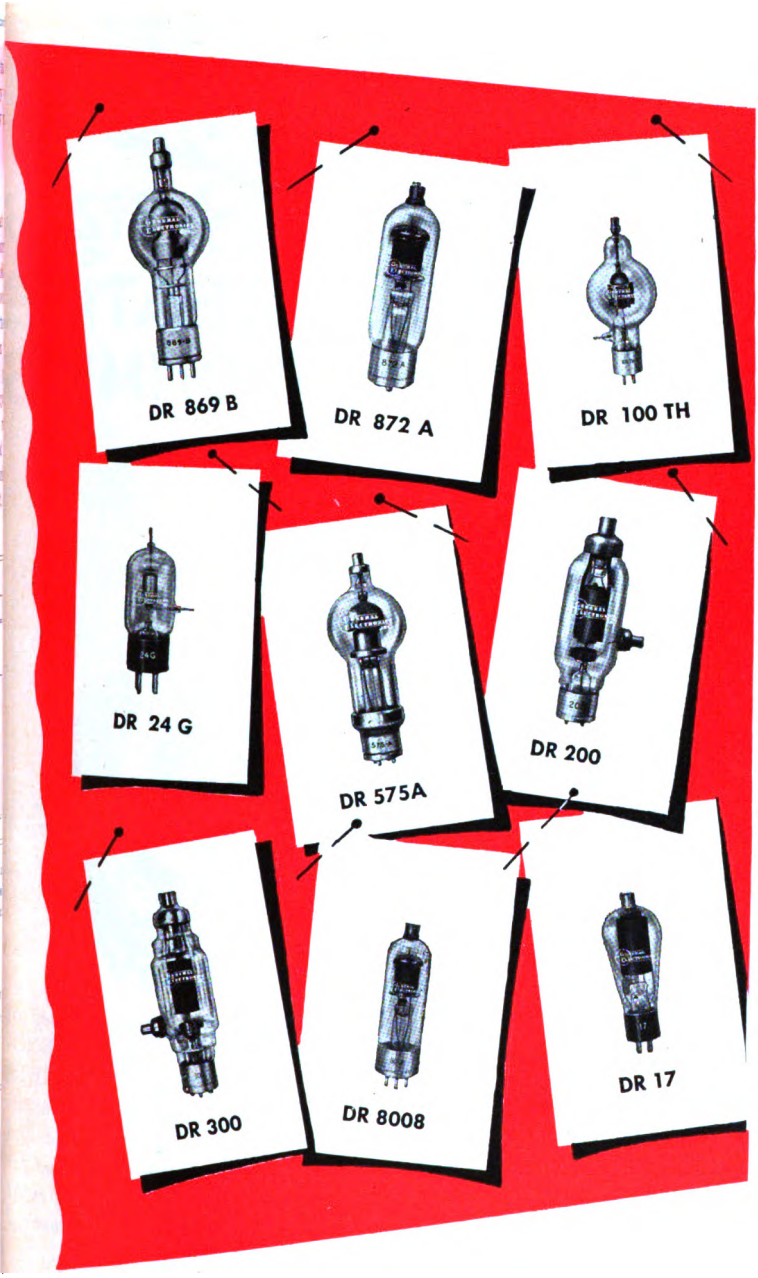

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absent, the assembly line was not affected.

Illustrated in Fig. 1 and 2 is a simple assembly in orthographic and in isometric exploded view. In the orthographic view at least two or three views are commonly required to identify the correct order of assembly, whereas in the isometric one drawing is required. Also it has been found that there is more assurance of the parts being correctly assembled by the neophyte worker during the first few hours of breaking-in time.

Isometrics is especially useful in showing wiring of radio parts in the chassis assembly. Figure 3 shows this wiring and when finally

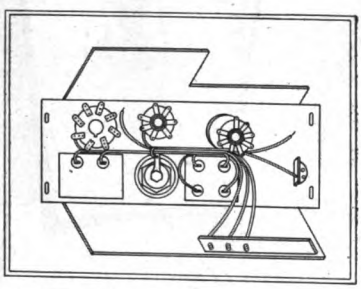

FIG. 3—Chassis wiring in isometric view. Color can be used to show coded wires

printed the wiring is shown in the wiring color markings. Another consideration is the time required for the preparation of the isometric drawing, since a trained draftsman can easily halve the time required to make an orthographic projection drawing.

Procedure

A method much in use is for a hubsman or layout man to make a complete layout in isometric of a certain section of the equipment, as in Fig. 4. Then the isometrician's assistants or draftsmen draw the subassemblies from this master drawing. See Fig. 4(a) showing a section of (b). This method of producing drawings has saved considerable time for the drafting departments. Sometimes the subassemblies are reduced in size to accommodate small chart folders, which are placed in front of each assembler with a print of the required assembly to be made.

Three more considerations are

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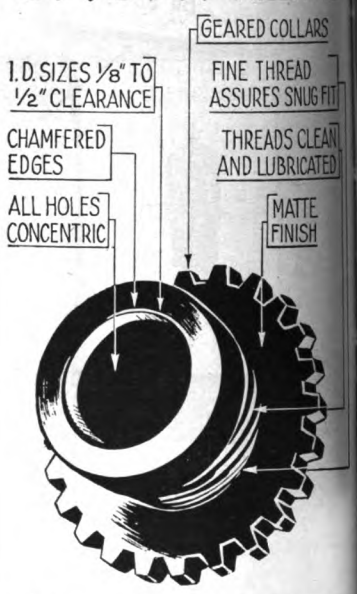

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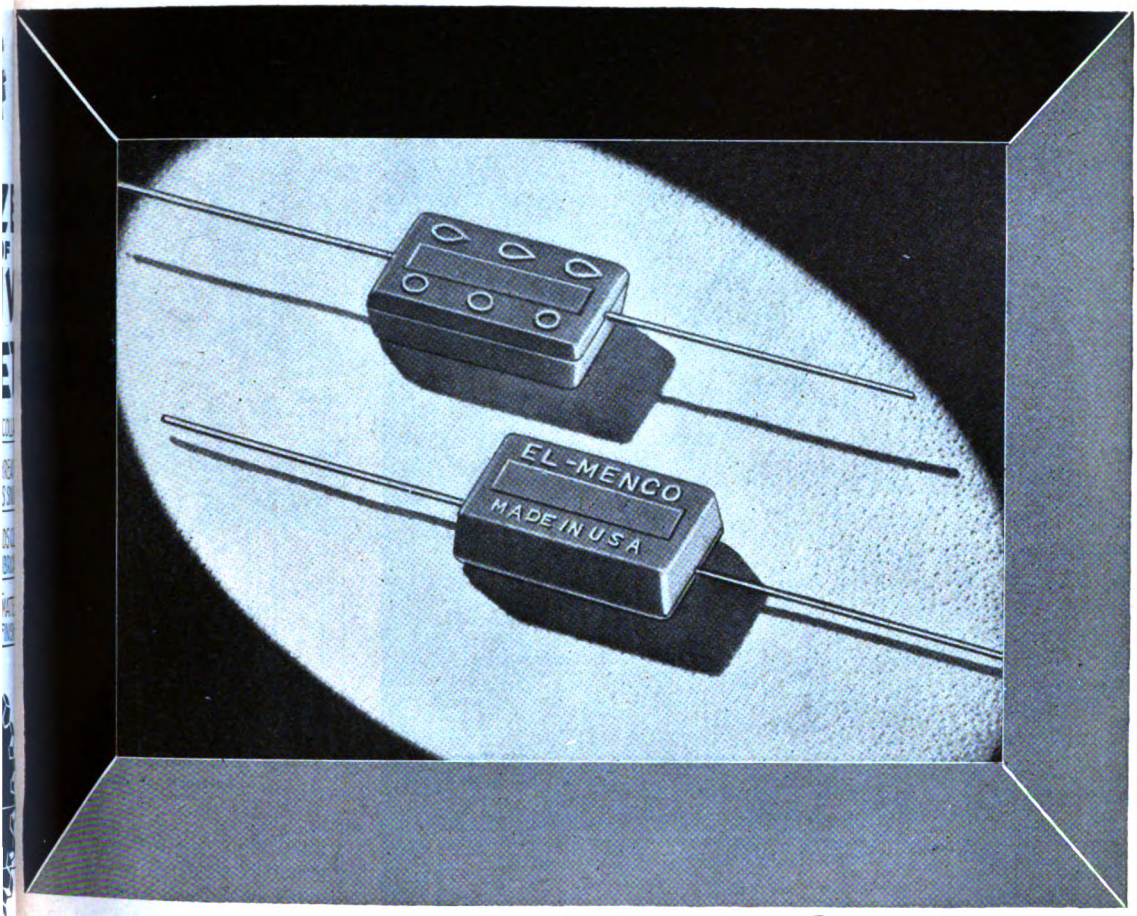

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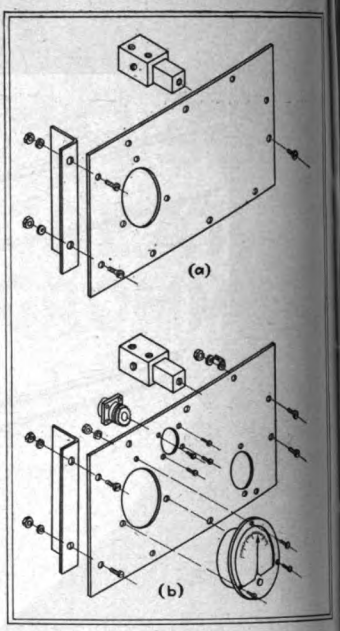

FIG. 4—An isometric layout of a complete panel is shown at (b). From this master, the view at (a) of the subassembly is drawn

important. One is that this type of assembly guidance does not tie up many small units used as models in the plant. A second is that, in the event of a change in the part, the isometric drawing revision is much simpler and less costly to make than the model used in the plant. The third is that inspection departments find it a great deal easier to use than the conventional orthographic assembly blueprints.

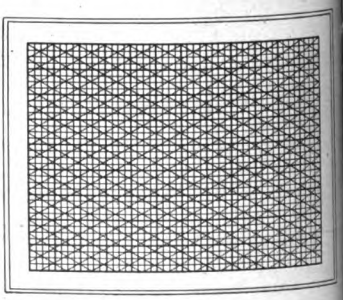

FIG. 5—Cross-ruled sheets can be used as guides if diagonal lines are added for making isometric drawings

The training time for most draftsmen in this type of work is anywhere from about three days to two weeks. The work can generally

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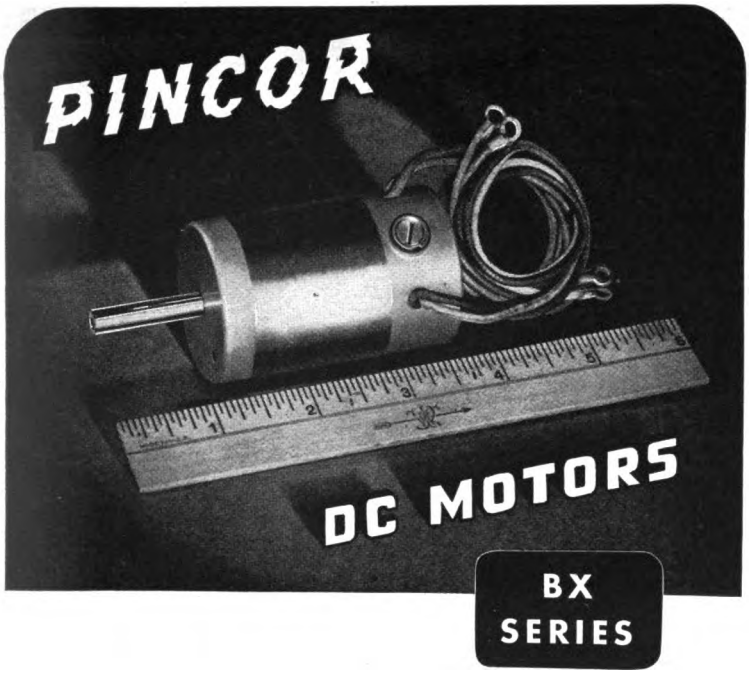

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be done from blue prints of assemblies or actual assembled parts.

Since isometric drawings are usually shown at 30-deg angles, a simple chart as shown in Fig. 6 can be prepared to use under the drawing sheet. It is prepared by drawing 64 squares to the square inch (such ruled sheets can be purchased), then diagonal lines are drawn in both directions at 30-deg angles at ½-in. intervals. However, there is available on the market a small size (8½ x 11) prepared isometric chart.

• • •

Electronic Equipment for Commercial Aircraft

By David William Moore, Jr.
Fairchild Camera and Instrument Corp.
New York City

To be a practical commercial conveyance, or a very useful private one, an aircraft must be capable of sustained operation through areas of limited visibility. This limitation of visibility, to be overcome, presents problems which are not encountered in any other type of vehicle. It was for many years an impossible problem to even determine the actual height above the ground. It still is a nice problem, but one which has been solved at least for large commercial craft by the application of electronics.

When the weather is such that visibility is limited to a very few feet, and no accurate altitude indication is available, no true ground speed and obviously no indication of the plane's exact location, flying can be far from enjoyable. This is just the predicament that flyers found themselves in not many years ago, before the days of radio ranges, automatic radio compasses, absolute altimeters, etc. It is, unfortunately, the state of the private flier even today due to the prohibitive cost of the available electronic aids, and of even the standard mechanical blind flying equipment. As private flying becomes more popular, accurate radio direction finders will undoubtedly approach a cost not much higher than good automobile radios. The radio range is available to anyone with a radio receiver, but radio altitude equipment will not be common on private

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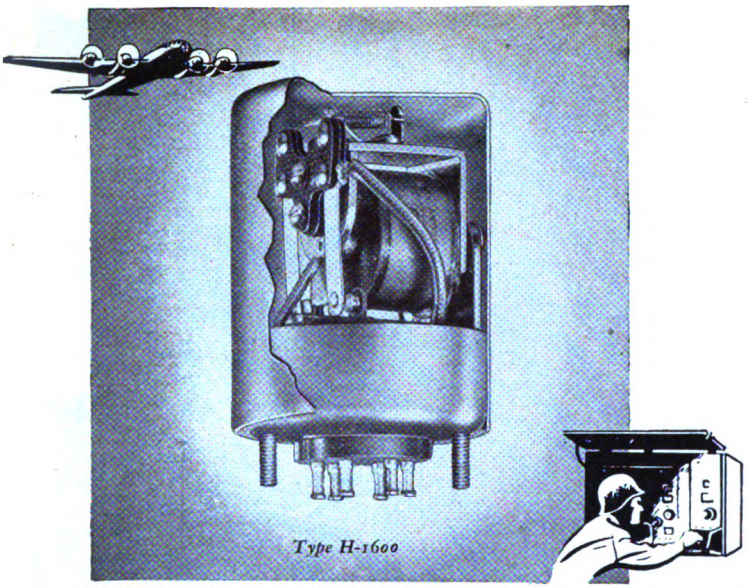

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Ice Indicator

An electronic instrument has been developed to warn the pilot of the formation of ice on his wing surfaces, a very serious problem in cold weather flying. There are so many different forms of ice, and such widely varying rates of ice-creation that satisfactory detection has been and is still difficult. Electrical instruments are being developed in competition with the electronic type. The main problem is to determine the rate of ice formation so that a pilot can, upon changing his course, decide whether conditions have been improved or not.

The formation of wing and tail surface ice has been practically solved on large aircraft, experimentally at least, by the use of heated wings which preclude the possibility of any formation of ice. The propeller and the carburetor are not protected by wing heating and still offer possibilities for electronic detection. But the heated wing will probably never be practical for smaller aircraft where the

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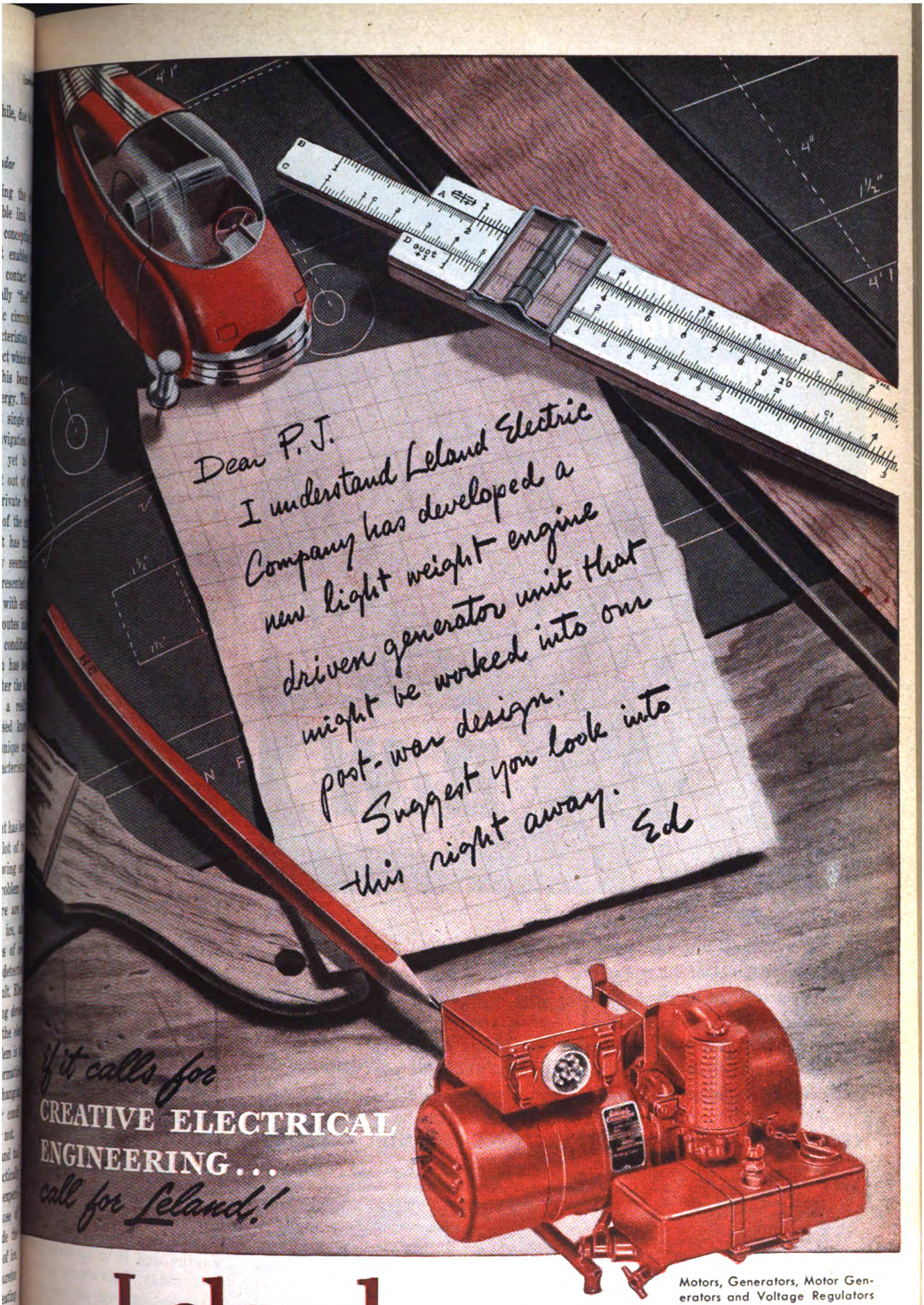

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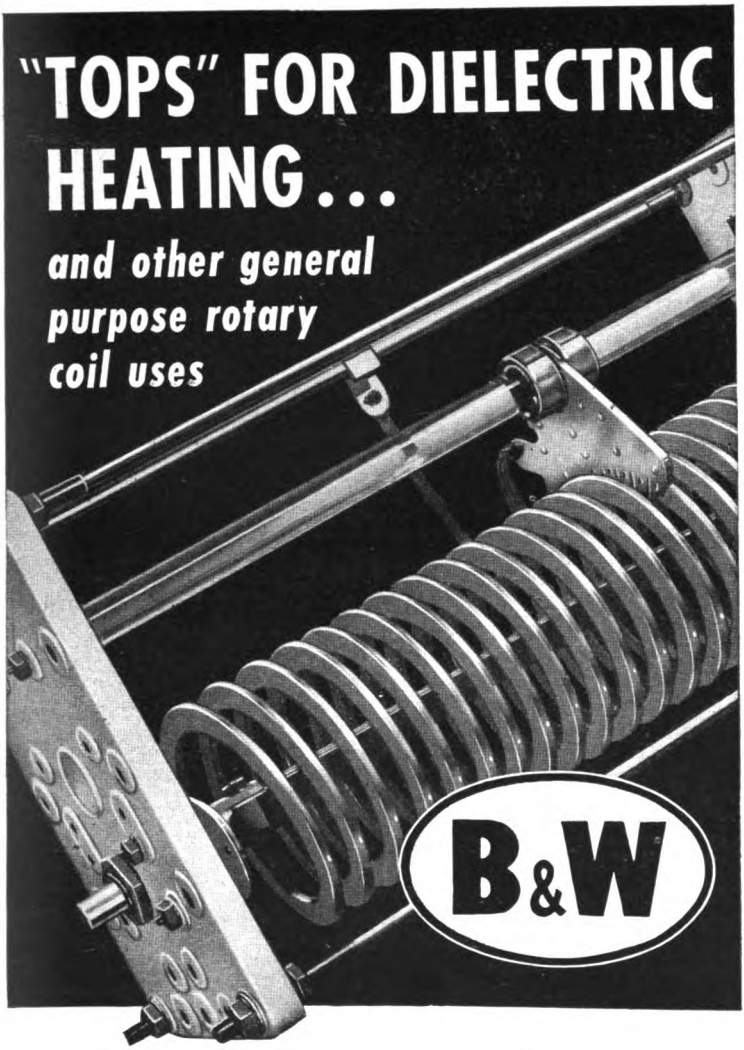

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addition of any weight at all is a matter of importance. Here a simple, reliable and practical ice warning detector will be of importance and will be undoubtedly available to those who expect at times to be caught out in the weather. A simple unit of this type should in time sell for less than fifty dollars.

Electronic Gas Gage

One of the many problems which still confront the makers of large aircraft is the accurate determination of the amount of gasoline in the tanks. This may sound like a simple problem but when you consider the various sizes and shapes of these tanks, and especially the flexible tanks which change shape with gasoline load, coupled with the various flight attitudes of large planes during even a normal flight, it is evident that a simple float type of gage will not provide accurate readings.

Accurate carburetion and fuel consumption control is of not too much aid if the amount of fuel remaining in the tanks cannot be measured in flight closer than five or ten percent. Electronic gages have been in service on some foreign craft, and are being experimented with in this country. These gages measure the capacitance between a plurality of plates immersed in the gasoline, the capacitance being a junction of the height of the gasoline between the plates. A gage of this type may be designed to compensate for moderate changes in plane altitude and several tanks may be connected together and totalized. Commercial airlines will welcome an accurate fuel gage since any excess fuel carried merely because of uncertainties is wasted money and is reflected in higher operating costs.

Electronic Supercharger

An electronic unit has been developed to control the boost, or manifold pressure of an aircraft engine and is in successful operation today. This control maintains a predetermined air pressure at varying altitudes by controlling the setting of the superchargers waste gate. A description of this unit was published in ELECTRONICS.

Controls of this type will un-

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...WHERE ONLY THE BEST WILL DO

In a comparatively short time, the mighty bombers of the Army Air Force can pass from the scorching heat of the tropics to the frigid subzero climate of the stratosphere where electrically heated flying suits become an absolute necessity for the protection and efficient operation of all personnel. Vital parts of these "hot suits" are the Durez plastic electrical connectors illustrated here.

Probably no other field of industry requires the versatility in a material as electrical manufacturing. Such properties as dielectric strength, heat resistance, moisture resistance, impact strength and dimensional stability at temperature extremes, are basic "musts" in practically all cases.

Because the phenolics are the most versatile of all plastics, their use in this highly specialized field naturally is tremendous. Typical examples of this large utilization are these electrical connectors molded for the Holwin Corporation by Northwestern Plastics Company.

Close Tolerances

As the result of an ingenious molding operation, these electrical connectors are efficiently molded by a single operation. Fastening nut locating holes, as well as spring contact grooves, are molded-in. The specifications call for close tolerances on these grooves which attest to the excellent moldability and exact shrinkage of the Durez phenolic molding compound used. *Further evidence of a plastic that fits the job.*

Versatile Plastic Used

The wide range of properties which the Durez compound selected for this job possesses, are also found, in varying degrees, in all of the other more than 300 Durez phenolic molding compounds. In addition to those mentioned before, they possess such properties as lustrous finish, arc-resistance, and resistance to mild acids and alkalies—to mention a few. This unusual versatility makes their applications almost limitless... makes them of unusual value to the design engineer.

As specialists in the production of phenolics for the past quarter century, Durez technicians have the extensive experience so necessary to advise you expertly. The benefits which this rich background and a wealth of proved product development data can provide, are available to you and your custom molder at all times. Durez Plastics & Chemicals, Inc., 327 Walck Road, North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

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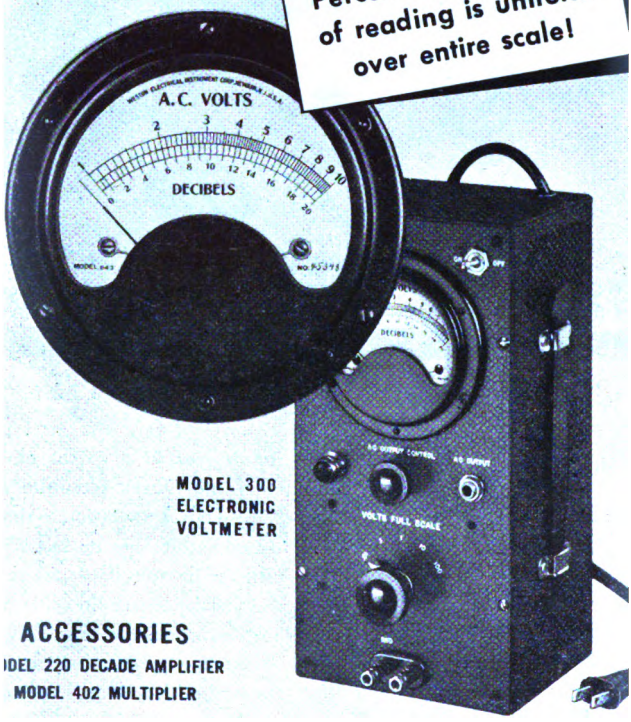
LECTRONIC AC VOLTMETER

with Logarithmic Scale

Percentage Accuracy of reading is uniform over entire scale!



MODEL 300
ELECTRONIC
VOLTMETER

ACCESSORIES

IDEL 220 DECADE AMPLIFIER
MODEL 402 MULTIPLIER

Since its development in 1935 the Ballantine Electronic AC Voltmeter is the only instrument of its kind with a Simplified Logarithmic Scale.

The important feature of logarithmic scale indication in the Ballantine Voltmeter provides the same degree of accuracy at 1 as at 10. Also the simplicity of this scale reduces errors in visual observation, common with most multi-range instruments. Finally, the care taken in overall calibration combined with the inherent stability of the circuits used permits reliable readings within the 2% specified tolerance over the complete range of operation.

Write for descriptive technical Bulletin 8

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

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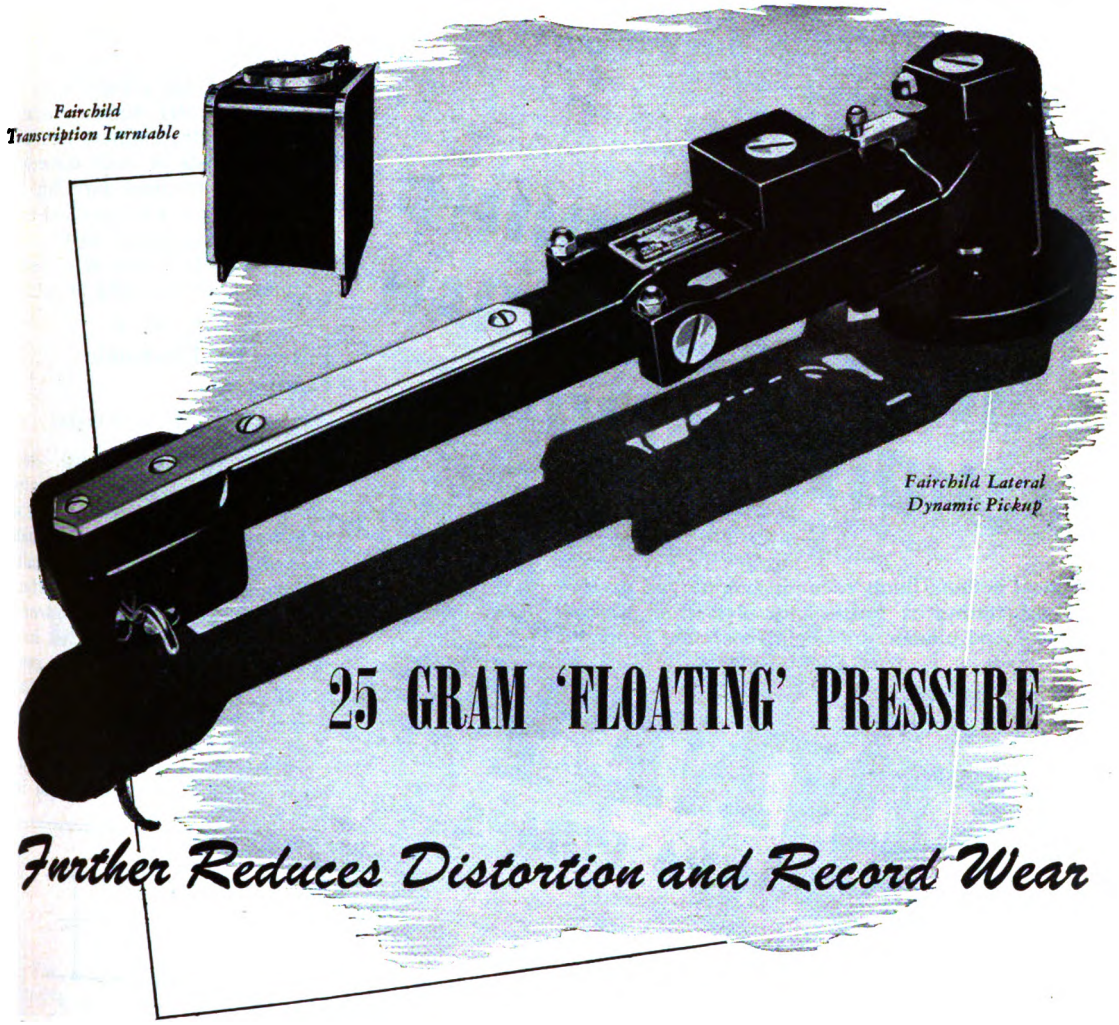

Fairchild Transcription Turntable

Fairchild Lateral Dynamic Pickup

25 GRAM 'FLOATING' PRESSURE

Further Reduces Distortion and Record Wear

FAIRCHILD offers an unusually mounted 'floating' design for low-pressure, dynamic pickup. Designed for radio broadcast and other exacting transcription requirements, it reproduces all of the quality and natural beauty of recorded music or speech *with full naturalness.*

All microscopic undulations — that determine the quality of the transcription — are picked up without distortion *even from heavily modulated grooves.*

How? By means of several Fairchild patented design features: Let's start with the 3 ounce cartridge mounted on a two-point suspension in the pickup head casting. It's the only vertical moving mass in the Fairchild assembly. High and low spots in the record disc need only displace its 3 ounce weight instead of the total weight of the entire mounting arm. This unusual mounting method affords a near-uniform stylus pressure of 25 grams — even under unfavorable playing conditions.

Next, the pickup head is mounted in the famous Fairchild tone arm with cone ball bearings. Lateral drag is reduced. And still another important source of distortion and record wear is eliminated.

Finally, there is no *overhang* of the tone arm with consequent inertia — another cause of difficulty when playing warped records or on uneven turntables. The tone arm *floats* at any required adjustable height above the disc.

Descriptive and priority data on the newly perfected Fairchild Lateral Dynamic Pickup and Transcription Turntable are now available. Address *New York Office:* 475 - 10th Avenue, New York 18; *Plant:* 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

Fairchild CAMERA AND INSTRUMENT CORPORATION

SOUND EQUIPMENT

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FIGURE THIS ONE OUT . . .

HARDLY ANYTNING IS MORE USEFUL THAN ALMOST NOTHING

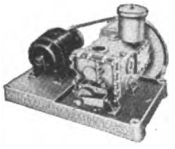
Webster defines high vacuum as space almost devoid of content — hence *almost nothing.*

Almost nothing (high vacuum) has played an important part in manufacturing or processing: electronic devices, light bulbs, dried blood plasma, and countless other products.

KINNEY HIGH VACUUM PUMPS

For nearly two decades, Kinney has supplied reliable vacuum pumps. In many industries, Kinney Vacuum Pumps have removed high vacuum processing from the laboratory to large scale factory production. Today, nearly three thousand Kinney Pumps are at work in electronics, over two thousand in electrical production and thousands more in metals, petroleum, pharmaceutical, chemical and miscellaneous industrial applications. These vacuum pumps, with a total displacement of over 710,000 cubic feet per minute, represent a vast fund of experience in designing and building pumps for the specialized service of creating and maintaining low absolute pressures.

Let Kinney figure out your vacuum pumping problems



Model CVD Compound Dry Vacuum Pump. Low absolute pressures 0.5 micron or better.

KINNEY MANUFACTURING COMPANY

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We also manufacture

Vacuum Tight Valves, Liquid Pumps, Clutches and Bituminous Distributors

ally being improved. A good transmitter and receiver will be almost a must in post-war private flying if any cross-country flight is anticipated. Both transmitters and receivers as well as radio direction finders in more simple form will be available to private flyers and will probably be similar in construction to high-grade automobile radio equipment, and similarly priced.

• • •

Filters for Electronic Equipment

By GERSHON J. WHEELER

MANY MODERN INDUSTRIAL electronic devices and auxiliary units are sources of r-f noise covering a wide range of frequencies. As such they interfere with radio communications in all bands. This interference is picked up by the antenna of the receiver or is fed back into the power lines. If the noise generator is in a well-shielded box, then power-line filters should eliminate the interference.

There are a few practical precautions which are not mentioned in

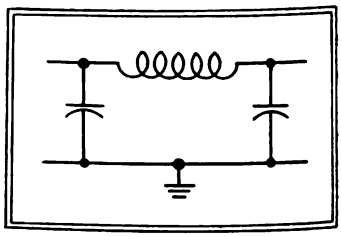

Fig. 1—Popular pi-type of filter under discussion

the textbooks. Most filters for this application are broadband pi-type configurations consisting of two capacitors and a choke (Fig. 1). Although the larger the choke, the higher will be the attenuation, care must be taken not to make this too large. If the reactance of the choke at the line frequency is too high, the resultant voltage drop would prevent the equipment from operating properly. For example, a 250-microhenry choke in a 110-volt, 800-cycle line (this is not an uncommon line frequency today) would have a reactance of 1¼ ohms. If the equipment draws 20 amperes, the drop across the choke would be 25 volts.

In a-c circuits, and especially at

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speed plywood bonding WITH R F heating

Illustration shows laboratory set-up.

The amazing advantages of radio frequency heating in plywood bonding are clearly shown by this demonstration which heated 2560 cubic inches of plywood (16″ x 16″ x 10″) to a uniform temperature of 270° in 5 minutes.

This is typical of the fast, accurate performance of radio frequency heating. And these compact, easily-installed Westinghouse RF Generators offer many advantages in all types of plywood bonding.

Timing is automatic, for example, and heat after heat can be repeated automatically without interruption, or duplicated in any future job with perfect accuracy. Pushbutton operation is quick and easy and once the Westinghouse heating unit is adjusted to a process, operation merely requires pushing a button and setting dials to calibration data.

RF heating cuts processing costs, too, for power consumption is limited to the amount needed for the operation. The line of Radio Frequency Generators similar to that shown here has wide flexibility in plywood bonding. Operators are protected by dead-front construction.

Your nearest Westinghouse office can give you complete details on the use of radio frequency heating in bonding plywoods. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

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Electronics at Work

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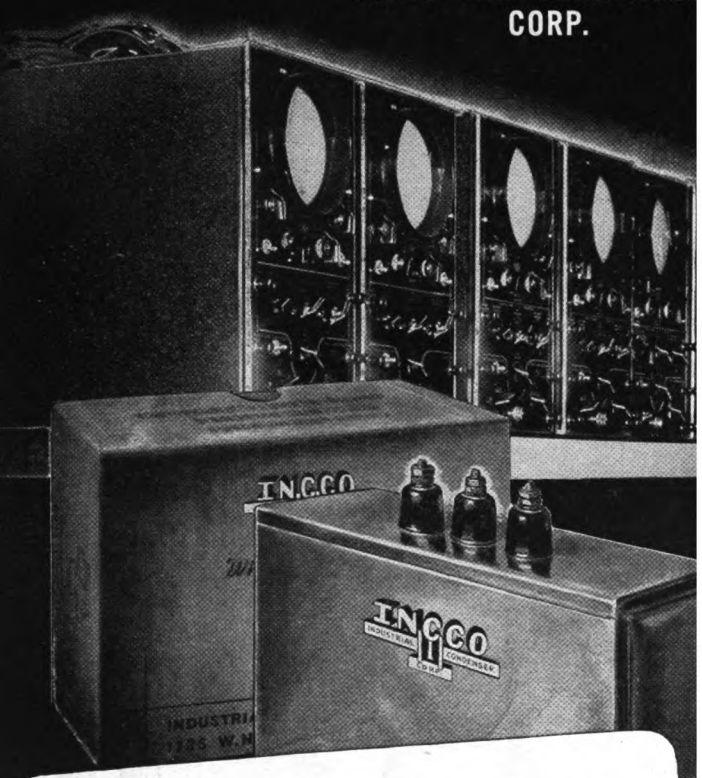
WORLD FAMOUS OSCILLOSCOPES by DUMONT

Use Capacitors by
INDUSTRIAL CONDENSER CORP.



Capacitors used in Dumont's famous oscilloscopes are especially designed, engineered and manufactured for unusual performance under difficult operating conditions.

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INDUSTRIAL CONDENSER CORPORATION

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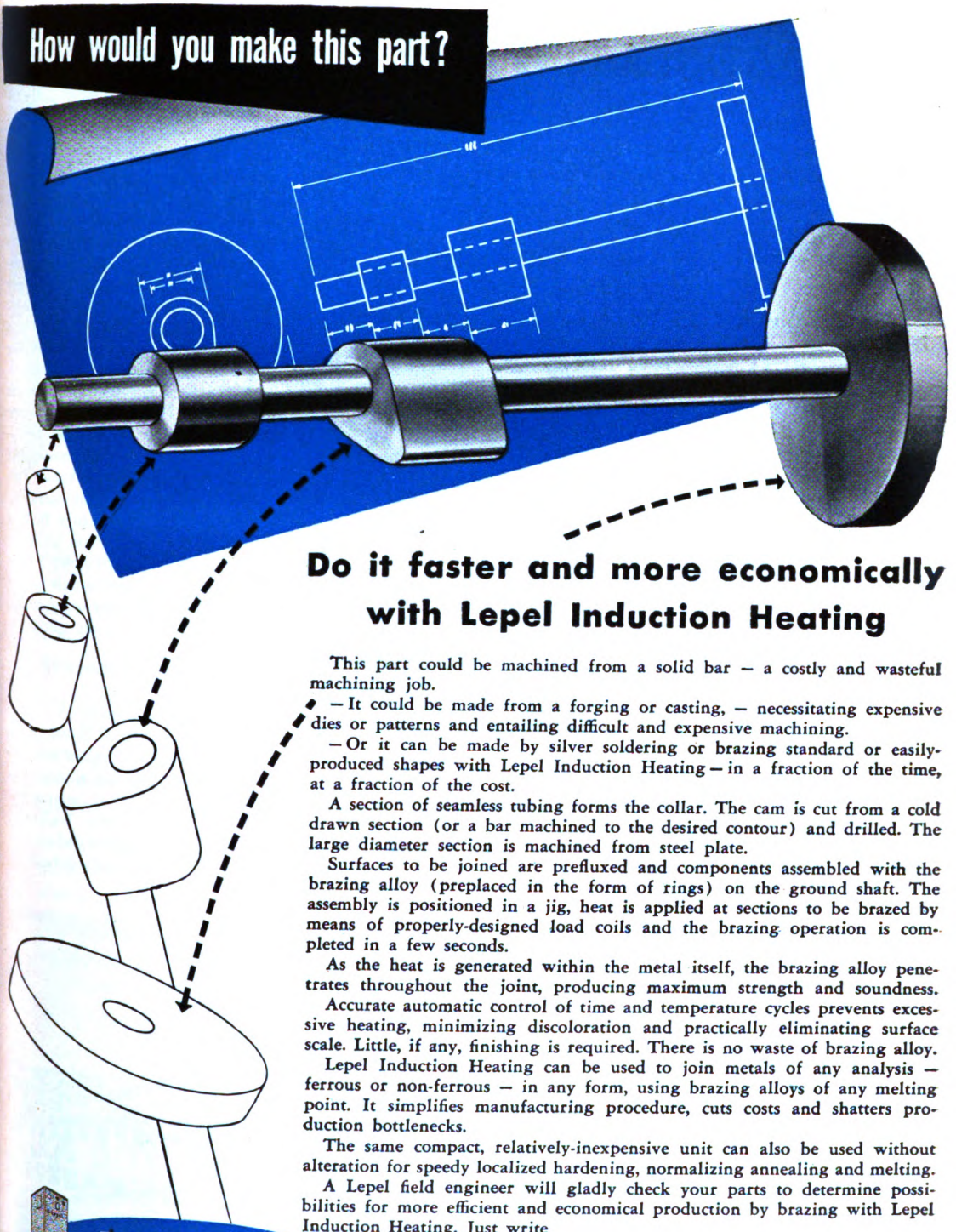
How would you make this part?



Do it faster and more economically with Lepel Induction Heating

This part could be machined from a solid bar — a costly and wasteful machining job.

— It could be made from a forging or casting, — necessitating expensive dies or patterns and entailing difficult and expensive machining.

— Or it can be made by silver soldering or brazing standard or easily-produced shapes with Lepel Induction Heating — in a fraction of the time, at a fraction of the cost.

A section of seamless tubing forms the collar. The cam is cut from a cold drawn section (or a bar machined to the desired contour) and drilled. The large diameter section is machined from steel plate.

Surfaces to be joined are prefluxed and components assembled with the brazing alloy (preplaced in the form of rings) on the ground shaft. The assembly is positioned in a jig, heat is applied at sections to be brazed by means of properly-designed load coils and the brazing operation is completed in a few seconds.

As the heat is generated within the metal itself, the brazing alloy penetrates throughout the joint, producing maximum strength and soundness.

Accurate automatic control of time and temperature cycles prevents excessive heating, minimizing discoloration and practically eliminating surface scale. Little, if any, finishing is required. There is no waste of brazing alloy.

Lepel Induction Heating can be used to join metals of any analysis — ferrous or non-ferrous — in any form, using brazing alloys of any melting point. It simplifies manufacturing procedure, cuts costs and shatters production bottlenecks.

The same compact, relatively-inexpensive unit can also be used without alteration for speedy localized hardening, normalizing annealing and melting.

A Lepel field engineer will gladly check your parts to determine possibilities for more efficient and economical production by brazing with Lepel Induction Heating. Just write

Lepel High Frequency INDUCTION HEATING UNITS

LEPEL HIGH FREQUENCY LABORATORIES, INC.

PIONEERS IN INDUCTION HEATING

General Offices: 39 West 60th Street, New York 23, N. Y.

DO IT FASTER, BETTER, MORE ECONOMICALLY BY LEPEL INDUCTION HEATING

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TUBES AT WORK

Sixty Kilowatts On Wheels Serves Signal Corps 208
Time Division Multiplex, Eight Channels—One Transmitter ... 212
Compressed Recordings for Carrier Pigeons 220
Improved Bass for Small Radios 224
Tubes Calibrate Heavy Artillery 240
Postwar Prospects for Modulated Pulse Transmission 244

Sixty Kilowatts On Wheels Serves Signal Corps

A SIXTY-KILOWATT mobile radio station, the largest ever constructed, is now operating in Europe for the U. S. Signal Corps. Called SigCircus and designated officially as mobile radio station P-563, it occupies 17 large trailers and contains the facilities of a fixed station of similar power.

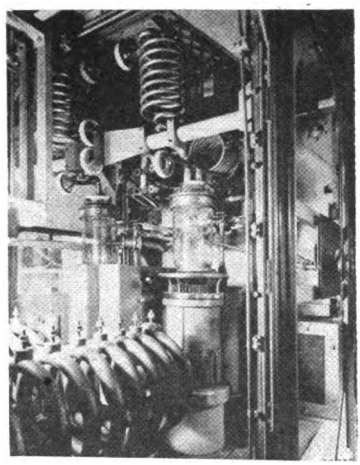
SigCircus can transmit and receive a total of 200,000 words daily. Besides the normal radio-teletype channels, for simultaneous transmission and reception between Europe and the United States, the station has complete broadcast facilities. These include a modern broadcast studio and control booth, a portable American Forces Network studio, complete equipment for two-way facsimile operation, and wire, film and disc recording.

The station was ordered by Brigadier General Carroll C. Bickelhaupt, Director of Communication Division of the U. S. Army, on October 26, 1944 from Le Materiel Telephonique, French associate of International Telephone and Telegraph Corp., and was delivered on schedule within three months after the original contract date.

It was designed for broadcast service to the United States, and is also capable of providing local programs for the entertainment of Allied troops within a radius of 25 to 30 miles. All the services can be carried on simultaneously without interference.

Equipment

A special v-h-f inter-unit communications system is used between the radio transmitting and receiving groups, which are placed some distance apart to prevent mutual interference. This system includes



Air-cooled tubes of the intermediate power amplier of SigCircus

voice-frequency carrier equipment to provide the required number of keying controls and channels.

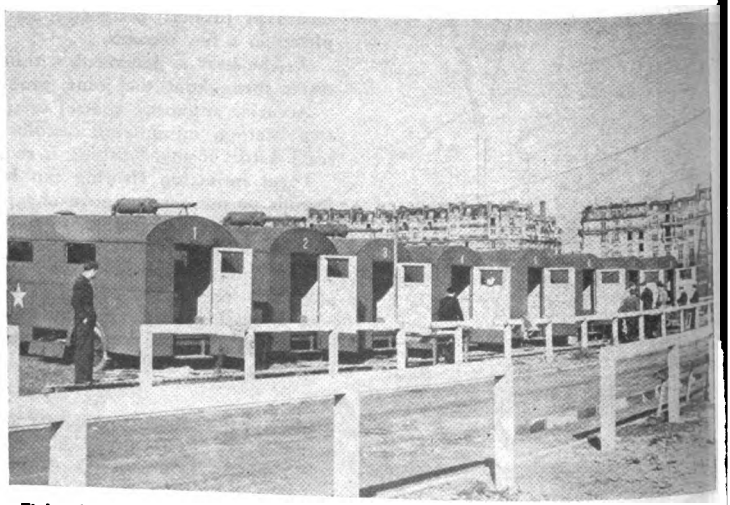
The equipment is distributed among the 17 trailers which are nominally divided into three general groups: transmitter, signal center, and power and pictorial.

In the first, or transmitter group, three trailers each contain a 50-kw Diesel power generator and a 275-gallon fuel tank. Switching from Diesel power to commercial power may be made when the latter is available. The fourth trailer contains a low-tension power supply and voltage regulator, with a 12-kv filter capacitor. Trailer 5 holds a high-voltage direct-current rectifier (12 kilovolts).

A Western Electric two-kilowatt driver unit is contained in another trailer together with v-h-f transmitters, receivers and associated carrier equipment. This trailer also contains the transmitter operating position. The driver stage feeds a 60-kw power amplifier in trailer 7, while trailer 8 has an Army Forces network transmitter, an air blower for its high power air-cooled tubes, a workshop and storage space.

Other Facilities

Five trailers numbered from 9 to 13 form the Signal Center group. Trailer 9 holds supplies and two v-h-f transmitter and receiver systems, while trailer 10 contains special carrier equipment. Trailers 11 and 12 have six high-speed teletype machines and associated facilities



Eight of the seventeen trailers that house SigCircus, the 60-kw mobile station of the U. S. Signal Corps now operating in France. Operated by Army personnel, it was designed and built by Le Materiel Telephonique, French associate of International Tel. and Tel. Corp.

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WHEN YOU REQUIRE OR SPECIFY Insulating Varnishes think of the CASHEW NUT...

. . . for from the shell of this delicious nut, Irvington produces HARVEL INSULATING VARNISHES that are tough as the combined strength of Elephant Hide and Walrus Back.

Once applied, by baking or air-drying, HARVEL sticks . . . it cures by polymerization to a solid, monolithic, fused state; protecting electrical equipment against acids, dilute alkalies, moisture, lubricating and transformer oils, high temperatures, etc.

HARVEL'S RESISTANCE TO HIGH TEMPERATURE IS OUTSTANDING . . . it retains its insulation resistance at temperatures up to 300° F.

HARVEL will not soften or "throw-out" at high peripheral speeds, has excellent dip-tank stability, exceptional penetrating power, the highest safety factor under excessive heat, heavy overloads and in atmospheres where acids, alkalies and abrasive materials are present.

HARVEL WILL NOT SUPPORT FUNGUS GROWTH.

Write for your copy of the "HARVEL INSULATION DATA BOOK" and the MITCHELL-RAND "GUIDE BOOK" OF ELECTRICAL INSULATIONS.

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- cures to a non-thermoplastic, infusible state
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- has excellent dip-tank stability
- insures constancy of electric properties
- has no objectional solvents that attack enameled wire
- bonds conductors into a compact unit-acting mass
- has exceptional penetrating power
- has excellent insulation value at high temperatures
- produces firm, tough mechanically strong coatings
- does not give off corrosive fumes
- resists acids, alkalies and moisture
- imparts high thermal conductivity to finished coils
- is recommended for Fiberglas and Asbestos windings

and WILL NOT SUPPORT FUNGUS GROWTH

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Cable Filling and Pothead Compounds
Fiberglas Varnished Tape and Cloth
Insulating Papers and Twines

A PARTIAL LIST OF M-R PRODUCTS

Fiberglas Saturated Sleeving and Varnished Tubing
Asbestos Sleeving and Tape
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth and Tubing

Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevings
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Insulating Varnishes of all types
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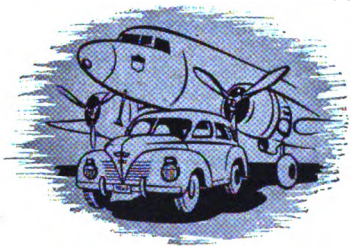
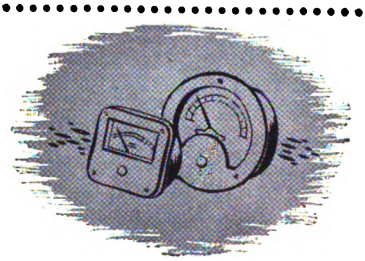
BETTER
PERMANENT MAGNETS
for:

RADIO, SOUND and
COMMUNICATIONS
EQUIPMENT

AUTOMOTIVE
and AVIATION
EQUIPMENT



INSTRUMENTS



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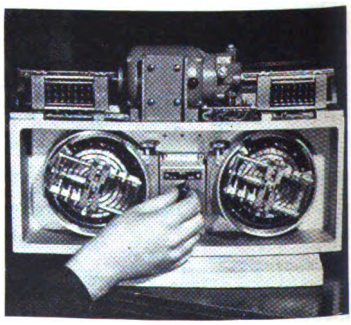
for handling traffic. Trailer 13 contains the facsimile transceiver units, the broadcast studio, and a control booth in which space has been set aside for the wire, disc and film recorders. This trailer is also the home of the portable American Forces network studio.

The receiving station, consisting of one W. E. receiver, v-h-f transmitters and associated carrier equipment, is fitted into trailer 14. In the power and pictorial group, two trailers each contain a 25-kw gasoline powered unit and another trailer carries the army pictorial division hut.

• • •

Time Division Multiplex System Uses Eight Channels With One Transmitter

A COMMUNICATIONS SYSTEM, by which eight channels are transmitted simultaneously by a single radiotelegraph transmitter, is operating between New York and London to increase communication capacity between the United States and Great Britain, and, with extension of channels to San Francisco, to expedite the flow of traffic to and from the United Nations Conference. The equipment can handle 488 words per minute inward and outward



This switch is being set for eight-channel service and also permits selection of two or four channels. At each side of the switch is a face-plate mechanism that feeds to or from the seven-unit printing equipment

simultaneously. This corresponds to eight channels each way with an individual channel speed of 61 words per minute. Operation may be made on four or two channels instead of eight channels, when desired.

The eight channels may be util-

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A	The Family of Monsanto Plastics — A guide for product designers	X500-4	Thalid for impression molding. Application information
B	Resinox — A Monsanto plastic	X500-5	Thalid — Glass cloth laminates. Physical properties
C	Lustron — A Monsanto plastic	X500-6	Thalid for impression molding. Data sheet
D	Monsanto Plastics — A data book for molders and fabricators	X800-1	Resimene 803-A. Melamine molding material
E	How Vuepak Helped 20 Manufacturers to Package for Greater Sales	X800-2	Resimene 801-K — Specifications. Molding laminating resin
F	Monsanto Plastics in Packaging	X800-5	Resimene 803-A — General
G	Monsanto Plastics in Toys	X800-6	Resimene molding compounds and resins
X100-2	Monsanto casting sealant	1000-1	Monsanto vinyl butyral
X200-1	Molding of Cerex	1000-3	Application of vinyl butyral
X200-2	Cerex data sheet	1000-4	Polyvinyl butyral dispersion
X200-3	Cerex—Applications	1100-1	Handling of Fibestos sheet
X300-1	Styramic HT (polydichlorostyrene)	1200-1	Lustron 2020 Improved Polystyrene
X400-1	Divinylbenzene	1300-1	Resinox 410 general purpose phenolic adhesive
X500-1	Thalid resins for impression molding. Fabrication information		

MONSANTO CHEMICAL COMPANY, Plastics Division
Springfield 2, Massachusetts

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☐ C	☐ X100-2	☐ X400-1	☐ X800-1	☐ 1000-1	☐ 1200-1
☐ D	☐ X200-1	☐ X500-1	☐ X800-2	☐ 1000-3	☐ 1300-1
☐ E	☐ X200-2	☐ X500-4			

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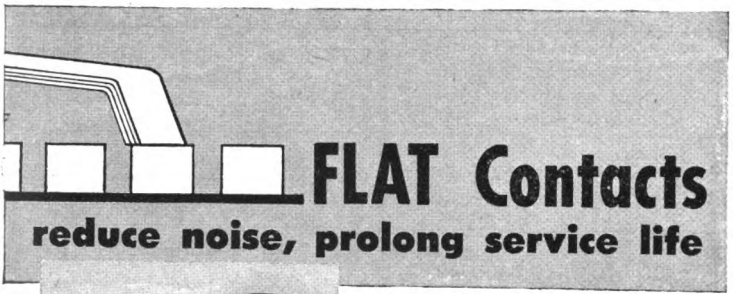
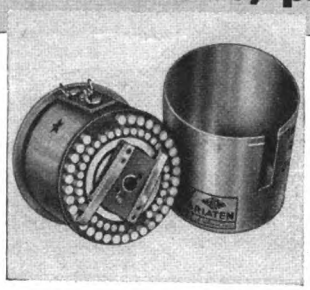
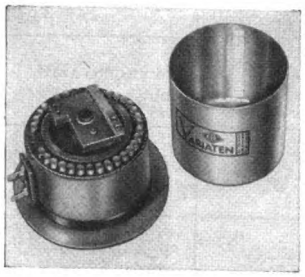


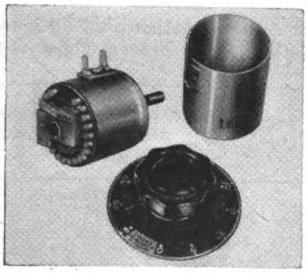
FLAT Contacts
reduce noise, prolong service life



VARIATEN #1218
"T" Circuit—1½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$17.50



VARIATEN #1156
Ladder Circuit—1½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$12.50



VARIATEN #1658
Ladder Circuit—2½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$5.75

VARIATEN contacts and brush surfaces make contact over their entire area because the contacts are ground flat and the brushes stone-lapped, *not* buffed. Buffing produces rounded surfaces and therefore a "point" contact highly susceptible to noise. Variaten brushes move from one contact to the next without rocking motion. The resulting perpendicular spring pressure at all positions allows us to take advantage of the natural resiliency of metals to provide a completely flat contact over the entire brush surface at all times and so reduce noise and lengthen service life.

No carbon resistors are used in any Variaten Mixer...
All are of stable, wire-wound construction. Most are step type. Where quiet operation is the major consideration, we recommend ladder type mixers because the circuit requires only one contact brush operation on the input side of the circuit and any possible brush noise is therefore attenuated along with the signal.

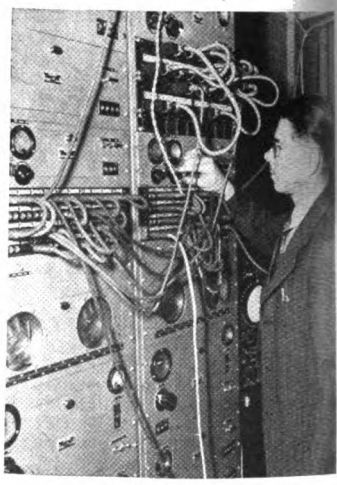
By all means compare circuits, construction and features of these mixers. From the hundreds of Variaten attenuators you may select the attenuators best adapted to your specific needs. Write for the Variaten Catalog today.

VARIATEN

CINEMA ENGINEERING CO.
Established 1935 • Burbank • California

ized for two-way communication with one distant station or four channels, with a total capacity of 244 words per minute, can be operated in both directions simultaneously between two different stations. Automatic retransmission of one or more of the channels to a third station, may be made.

Developed by RCA, the multiplex system uses a printing mechanism that makes the circuit practically error-proof, despite its high speed. If a letter be mutilated or garbled in transmission, a warning bell



Receiving and transmission panels used in the multiplex system developed by RCA. On each can be seen the front face-plate assemblies of the multiplex distributors that pass incoming or outgoing signal elements from and to the seven-unit printing equipment in the proper sequence and at the proper time intervals

rings at the receiving printer. Instead of the mutilated character, a Maltese cross appears to mark the exact spot of the error and facilitate correction.

Seven-unit Printer

Development of the new multiplex equipment began less than two years ago, but for some time before that date RCAC research engineers succeeded in the use of a seven-unit printer which is employed in the new system. Such a printer has been employed continuously since 1939 for handling commercial traffic over the New York-San Francisco radio circuit.

The printer is completely auto-

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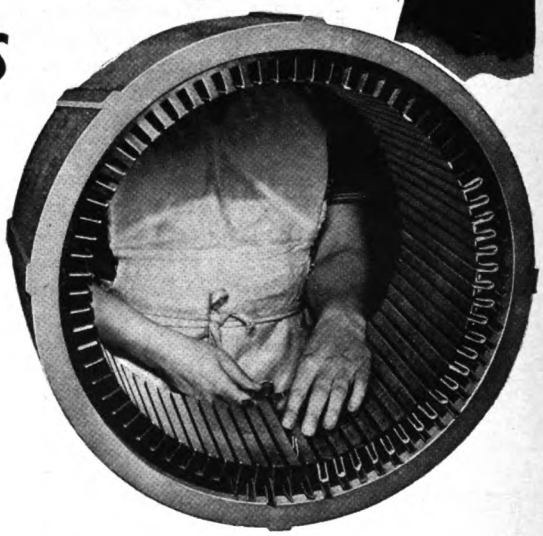

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matic and, in conjunction with the multiplex mechanism, the system functions with a minimum loss of circuit time. In the seven-unit system, each incoming letter is formed of three marking (signal) impulses, plus four spacing (no signal) impulses. Automatic counting is done in the receiving printer to check the arriving impulses, and if the marking impulses vary from three, the warning bell sounds and the Maltese cross appears to report an error.

The multiplex equipment is also able to handle other telegraphic codes. A different code can be used on each of the four pairs of channels if desired.

Routing Speed

Traffic from San Francisco to London passes through the synchronized equipment in the New York office of RCAC, at 66 Broad Street, where the channels are separated automatically. From there they go to the transmitting station at New Brunswick, then across the Atlantic. Routing from the British capital also includes passage through New York. A mechanical delay of only one-sixth of a second occurs in the transmission in either direction.

The system makes possible simultaneous transmission over four channels each way between San Francisco and London through New York, but the routing can be shifted, for instance, to send messages from either city to the Argentine over the three-channel New York-Buenos Aires circuit.

Each channel utilizes two bells for signalling. One rings when an incorrect group of signal elements reaches the receiving printer, and the other, of different pitch, is operated by means of a switch similar to a telephone dial. With it, the receiving operator can pass a number of stock phrases for service instruction to the other end of the circuit, thereby saving channel operating time.

• • •

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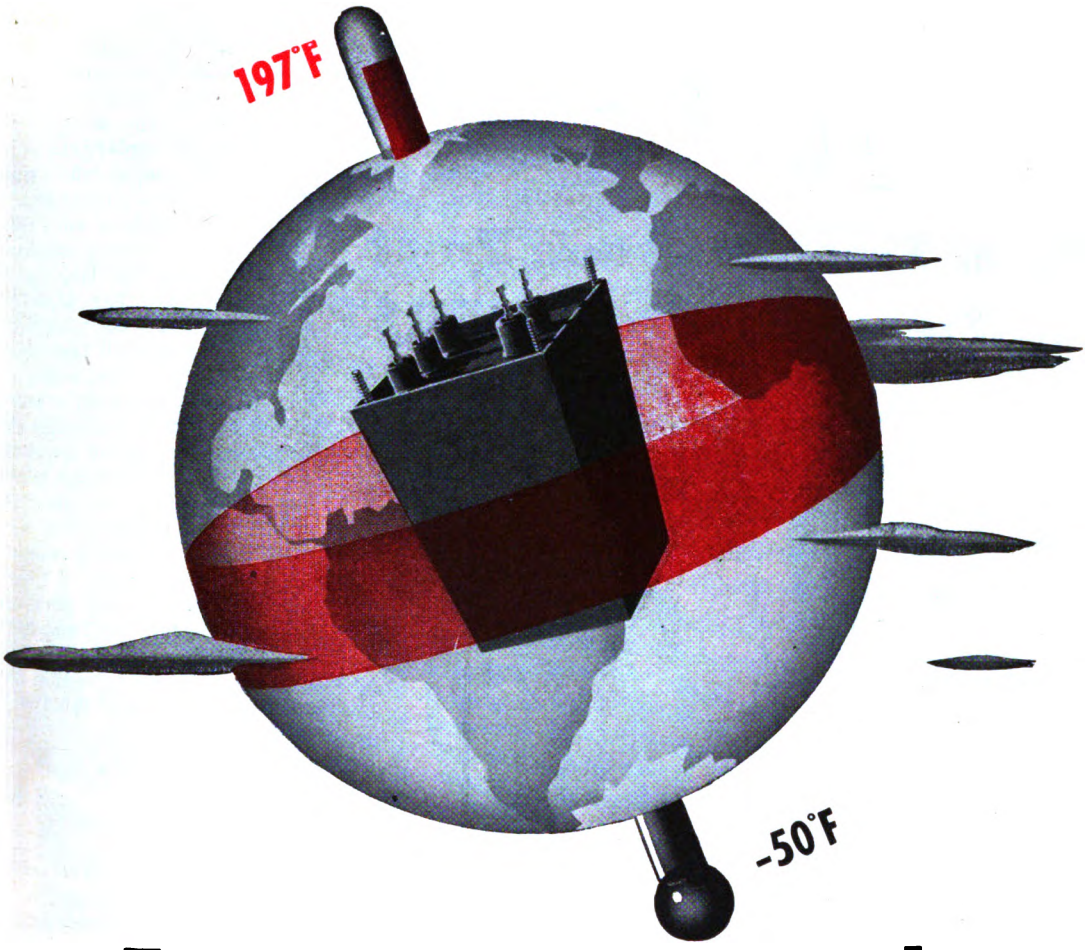

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Men of the U. S. Army Signal Corps say that no matter where they run their lines, "It's either too hot or too cold." To make sure equipment can take it, the Corps runs the five-cycle humidity test.

They were giving this test to a Thermador transformer. They put it into a chamber, pressed a button to get the bleak 50° below. They pressed another button, the thermometer shot to the 197° of a blazing equatorial noon. Five times they raised and lowered the temperature. They watched, through the glass doors, water dripping onto the transformers—condensation.

After forty-eight hours they took an ice pick to get at the terminals.

They wiped them dry, connected the current, threw on the switch. If, after this torture, the transformer could take 2,000 volts it would pass the test. They gave it not 2,000 but 4,000 volts, doubling the test—and, of course, it took it!

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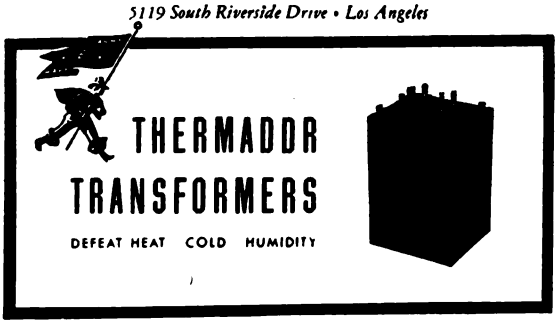

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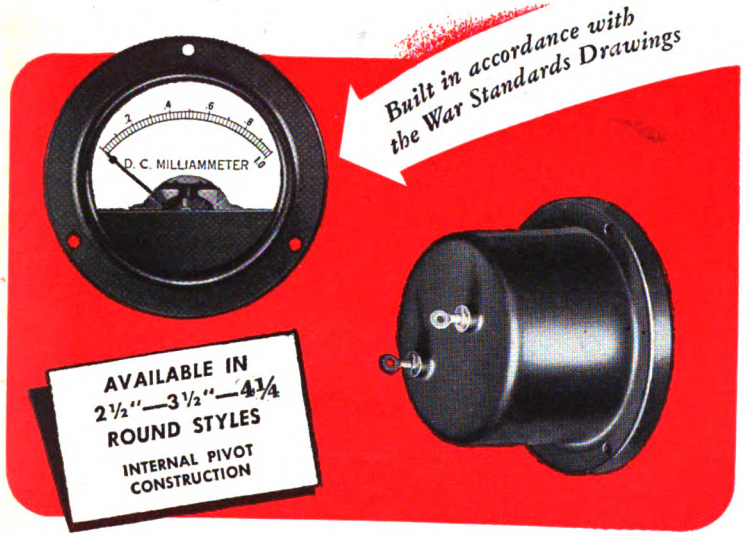

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back of homing pigeons, has been made possible by a recent improvement in sound recording sponsored by the Signal Corps. About twenty times as much wordage can be recorded on the film as can be typed on paper of similar surface area.

The film is made of ethyl cellulose, similar to ordinary cellophane. The belt is one foot long and 3½ inches wide, of which three full inches can be used for voice reproduction. The film belt takes thirty minutes to run its full course and can be turned inside out to take a similar recording on the other side so that one full hour of speech fills a single thin belt. Average talking has been found to run about 150 words to the minute, but some rapid talkers are able to enunciate 300 words per minute.

Approximately 18,000 words can be put on one film belt. Two belts fit into a four-inch capsule for harnessing to a pigeon's back, so that a single bird can carry 36,000 words of spoken message.

• • •

Improved Bass for Small Radios

SMALL LOUDSPEAKERS do not radiate efficiently at low frequencies. If one attempts to compensate for this deficiency by feeding greater low-frequency power to the speaker, the speaker will be driven to such an extent that it will introduce non-harmonic distortion.

The shock to the cone on reaching its limit of travel due to large signals will be translated into vibrations at speaker resonance. Because the cone will break into multiple modes of vibration, the radiation efficiency will be further lowered. The effect is that the speaker booms, not that there is greater low-frequency radiation.

Synthetic Bass Principle

It is not economically feasible in small receivers to use speakers that have flat response to low frequencies. The sizes of speaker and baffle are limited by the receiver dimensions, therefore poor low-frequency radiation is an inherent characteristic of small receivers and phonographs. Synthesized base provides a solution.

What makes such a system pos-

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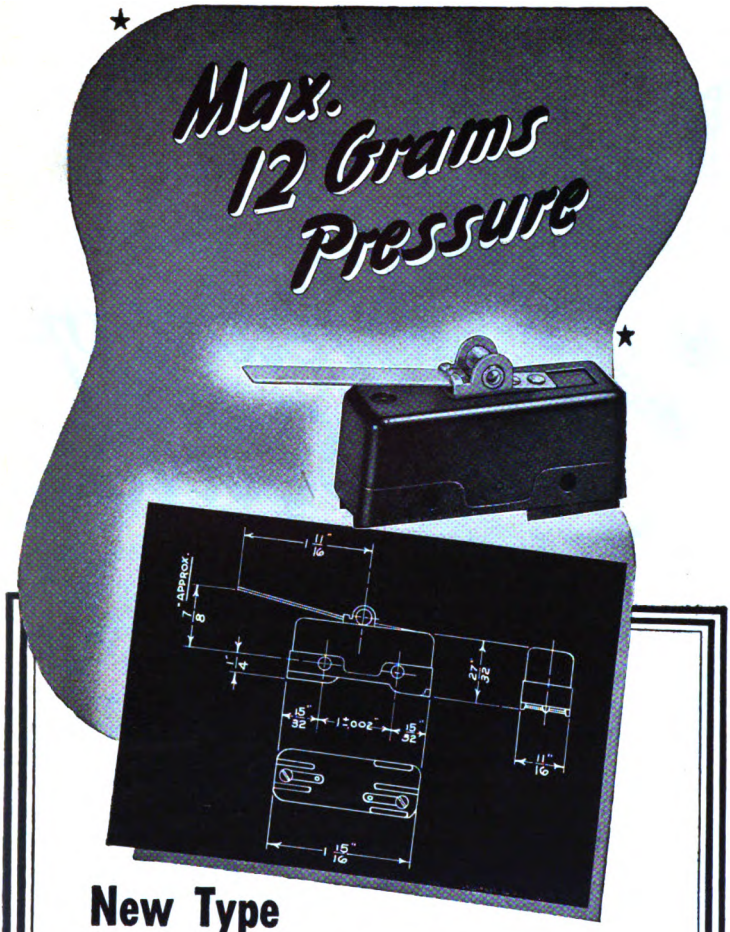

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sible is that the ear itself is a non-linear device introducing harmonics into the sound that it receives. Because of this characteristic of the ear, the aural effect of a low note can be produced by introducing into the ear the harmonics that the ear would generate itself if it were really receiving that low note. Physiologists have long known that a combination of odd harmonics of a low frequency give the impression to the hearing organs of the presence of that frequency even though the fundamental is itself absent. This characteristic of the ear is used by organists to play, in effect, notes that are lower than the ear can actually hear.

Applied to small radio receivers and phonograph amplifiers, the technique consists of introducing non-linearity into the output stage but only at low frequencies. This non-linearity introduces odd harmonics, chiefly third, in place of the low-frequency note. The odd harmonics are efficiently radiated by the speaker and heard and interpreted by the ear as if they were the low note from which the harmonic series was originally derived.

In taking advantage of the ear's characteristic to produce the appearance of low-frequency reproduction through the loudspeaker,

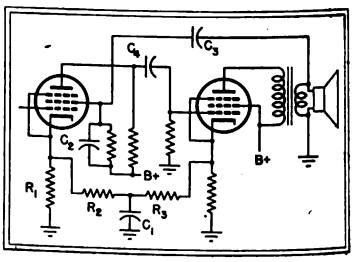

FIG. 1—Application of Synthetic Bass to the output of a typical table-model radio-phonograph, showing essential additions to the circuit

the system also augments the receiver's output characteristic to compensate for the changes in frequency response of the ear with volume level.

The ear's sensitivity for low tones at low volume is relatively less than its sensitivity for low tones at high volume. Thus in listening to low-level reproduction, to the ear the set appears to have less bass output

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than at higher levels. Or putting it another way, changing the volume—although it actually does not change the frequency response of the receiver—nevertheless gives the ear the impression that the frequency response has been changed. Nor is this effect limited to actual changes in receiver volume setting; quiet passages of music will be reproduced with apparently less bass than loud passages.

Circuit

The circuit incorporates automatic increase and decrease of the amount of effective bass response for loud and soft passages, introducing relatively greater bass at low volume levels than at high, thereby counteracting the ear's loss in bass sensitivity at low levels.

The circuit is shown in Fig. 1. Negative feedback in the output through C_3, by lowering the dynamic output impedance of the circuit, damps speaker-cabinet resonance which would otherwise become annoying noticeable with the increased bass response of the amplifier-speaker system.

Hum voltage from the positive high-voltage source is introduced onto the screen of the driver tube in such a polarity by the voltage divider C_2—C_3 as to counteract hum voltage on the plate, thereby lowering the hum signal. This humbucking circuit is especially necessary in a circuit whose function is to increase the apparent low-frequency response.

Third harmonic of the fundamental—necessary to give the aural effect of the fundamental—is produced by positive feedback through the network R_1—R_2—R_3—C_1. The action of the positive feedback can best be described in reference to the dynamic plate characteristic of Fig. 2. The tube is biased at the symmetrical mid-point of its characteristic. Positive feedback from a signal that has been affected by the tube's characteristic serves to emphasize the non-linearity of this characteristic. If however the signal is so small as not to be distorted in passing through the driver, there will be no increase in non-linearity.

The accentuation of the non-

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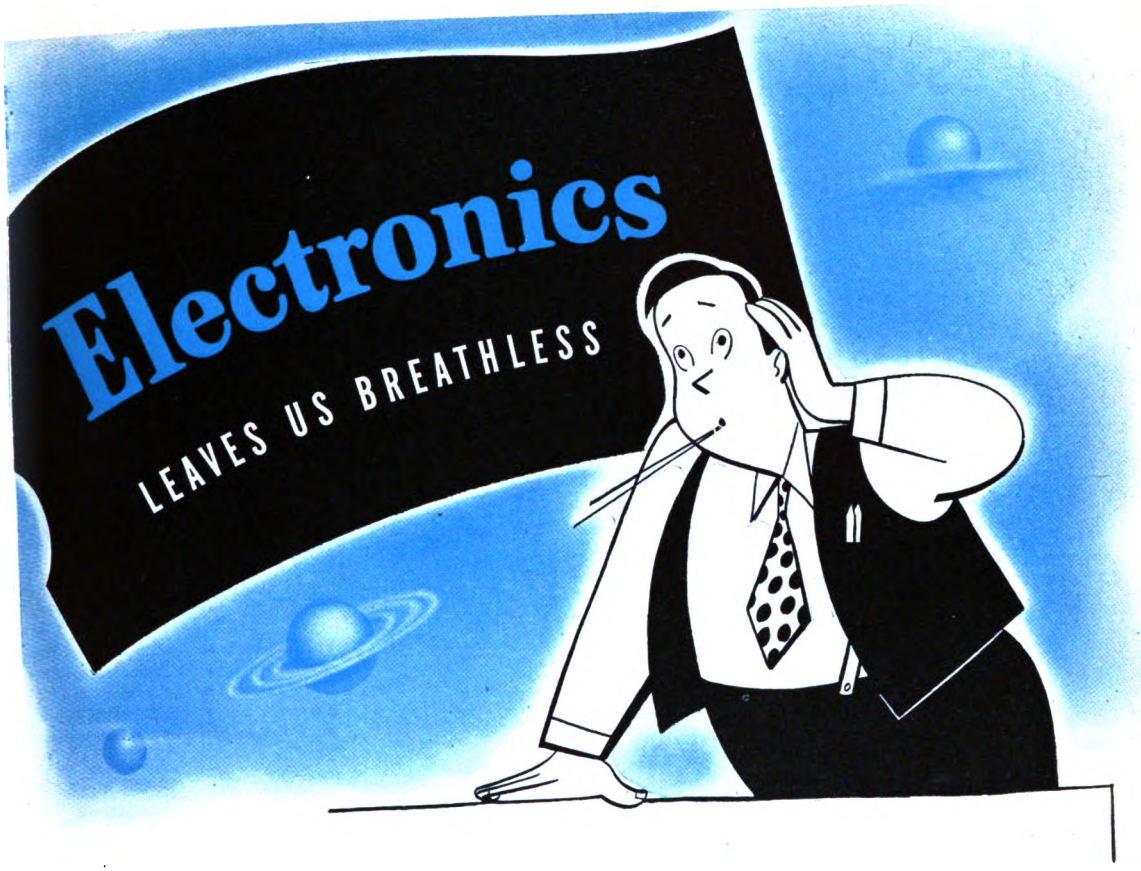

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linearity of the characteristic is limited to low frequencies by making the positive feedback network a low-pass circuit. The extremely non-linear but still symmetrical

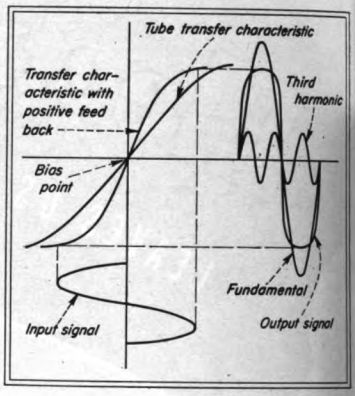

FIG. 2—Positive feedback accentuates non-linearity of the transfer characteristic, increasing generation of third harmonic necessary for aural appearance of bass response of small speakers

characteristic produced at low frequencies introduces strong third harmonics of these low tones.

To attenuate the strong low-frequency fundamental which could overdrive the speaker, the plate-grid coupling capacitor C_4 is made smaller than usual. The ratio of C_1 to C_4 determines the shape of the apparent speaker response, especially the frequency of maximum apparent response.

Acoustic Effect

The effect of the strong third harmonic in place of the fundamental is that, for a speaker which does not radiate low frequencies, acoustic output (taking into consideration all frequencies present in the output) is actually a rising response as frequency is reduced, thereby compensating for aural insensitivity at these low frequencies, instead of a rapidly falling response obtained if the speaker is required to radiate the fundamental. Acoustic output curves illustrating this bass synthesis and the volume-level bass compensation previously described are given in Fig. 3.

For additional information the reader is referred to two reports of the preliminary disclosure of the technique in a review of Shepard's

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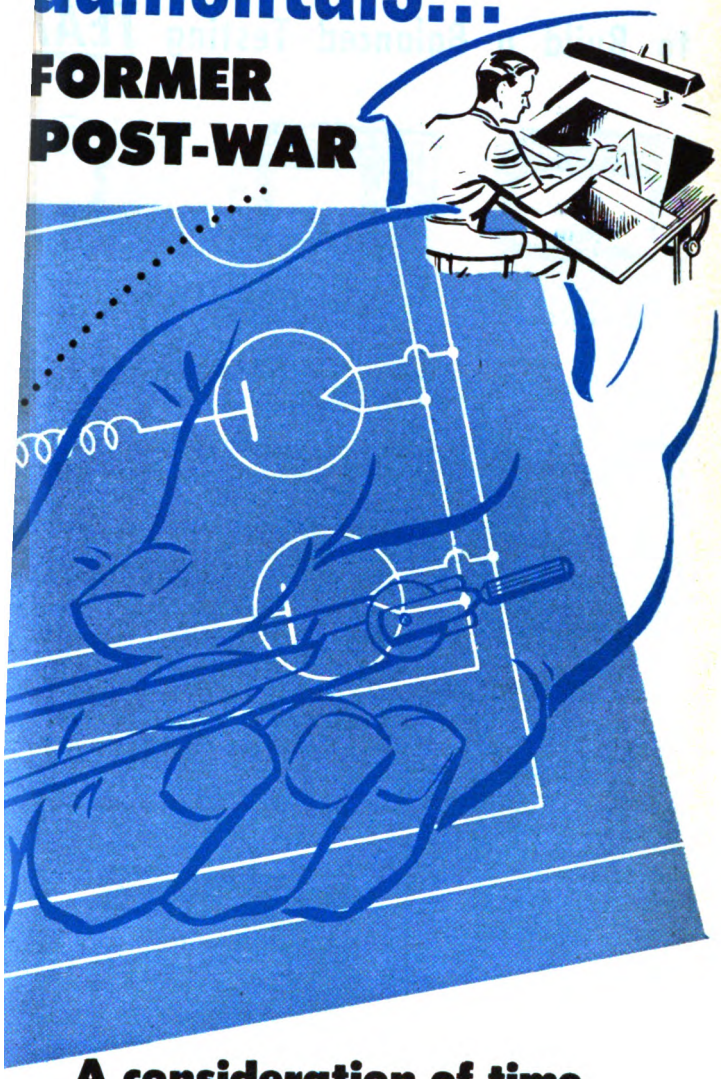

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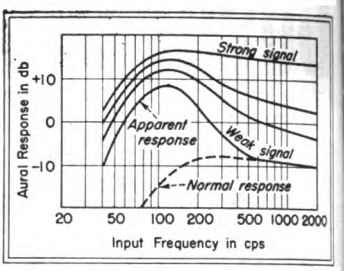

FIG. 3—Relative frequency-response curves indicate compensation for ear's change in sensitivity-frequency characteristic with intensity level and the aural appearance of notes below the radiation register of small speakers. Normal small-speaker response is shown by the dashed line; the solid lines indicate the apparent response using the synthesized bass arrangement

audio system in *Communications*, p 14, Nov 1941; and ELECTRONICS, p 31, Dec 1941 in which an early form of the circuit is given. The anticipated use for home radios and phonographs was reported in *Radio and Television Weekly*, p 6, April 18, 1945. Three patents (2,313,096; 2,313,097; 2,313,098) assigned to Revelation Patents Holding Co., 33 W 60th St., New York City 23, N. Y., describe the several principles of the circuit.

• • •

Tubes Calibrate Heavy Artillery

THE BATTLE USEFULNESS of American heavy artillery was extended by new electronic equipment used by Army Ordnance teams in Italy and Germany. The test units, installed in 2½-ton trucks and transported right up to the battlefront, are capable of measuring the speed of projectiles within 1/100,000 second.

The problem was to determine the velocity or speed of the projectiles of guns and howitzers that had been in service for several weeks or months, as compared with the velocity of new artillery pieces in action for the first time. When guns of different ages are fired together at the same target, allowances have to be made for each used gun. Figures for this purpose were provided by seven ordnance calibration teams that worked on the various battlefronts.

The results so far reported show

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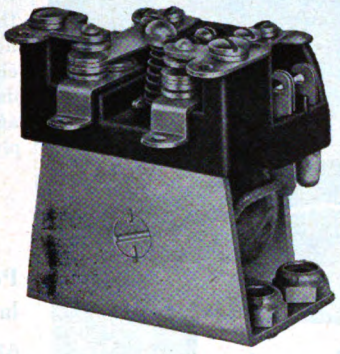
"BO" POWER RELAY

The "BO" relay is an all-purpose double pole power relay. Like other Allied types it is ruggedly designed yet features compactness and minimum weight. This relay utilizes molded Bakelite insulation throughout. Contact rating is 15 amperes at 24 volts DC or 110 volts AC non-inductive. The "BO" relay can be furnished normally open, normally closed or double throw and is available for either AC or DC service. Weighs 4 ounces.

Height 1⅞"; Length 1⅝"
Width 1 13/32"

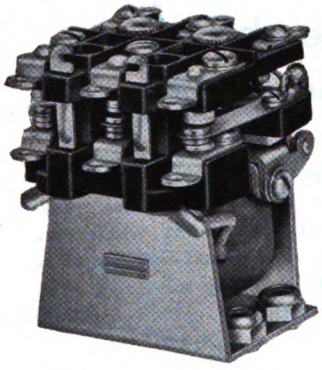


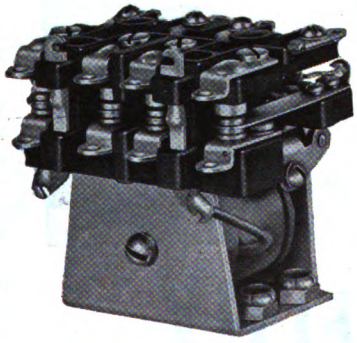
constant progress MARKS ALLIED RELAY DESIGN

"DO" TYPES 3 and 4 POLE

The "DO" three and four pole relay is similar in function to the "BO" type described above. It supersedes the old three and four pole type and features such modifications as simplified terminal arrangements, adjustable contacts, and improved mechanical structure. By using molded Bakelite insulation throughout, greater electrical clearance is provided. Contacts are rated at 15 amperes at 24 volts DC or 110 volts AC non-inductive. Can be furnished normally open, normally closed, double throw and for AC or DC service as specified. Weight for three pole type 7 oz., four pole 7½ oz.

Three pole Height 2¼"; Length 1⅝"; Width 1⅞"; Four pole Height 2¼"; Length 2 1/16" Width 1⅞".





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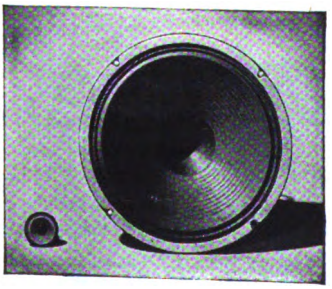

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that the life of gun tubes is much longer than previously assumed. In the past, gun crews discarded gun tubes rather frequently because they had no knowledge of the efficient life of a tube and could not afford to take chances. The electronic calibration units supply data on the condition of the tubes and helps reduce the artillery supply problem so serious in the Pacific.

• • •

Postwar Prospects for Modulated Pulse Transmission

AFTER NINE YEARS of research, pulse time modulation (PTM) has been announced by Federal Telephone and Radio Laboratories. The new system makes it possible to broadcast as many as 12 different programs simultaneously from a single radio transmitter operating on one frequency channel.

At the same time that it effects economy in transmission and simplifies and improves the efficiency of reception, it provides static-minimized reception of sound broadcasting.

Pulse time modulation receivers receive all radio programs on one frequency channel and are equipped with pushbutton circuits to separate each program after it is received. PTM transmissions differ enough from static to permit a PTM receiver to filter out noise.

The new system has been named PTM because the radio signals are transmitted in the form of short pulses, accurately timed. The time intervals between pulses in the new system, since it operates on very high frequencies, are extremely minute. Insertion of separate synchronizing pulses permits more than one program to be transmitted on a single channel. Reception of a particular program is accomplished by synchronizing the receiver through this pulse. Other programs, transmitted with differently synchronized pulses, are received by readjusting the synchronization in the receiver.

Advantages

Pulse time modulation is expected to have an application in tel-

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All through the war, as you would expect, TELEX has furnished the Signal Corps thousands upon thousands of midget Magnetic Receivers for grueling combat uses.

From lessons learned through this rich experience, TELEX today continues to pioneer with the newest and most advanced refinements and improvements in Magnetic Receiver construction and application.

For such postwar products as wearable radios, airport and airplane receivers, I. C. systems for railroads, telephone equipment, dictating equipment, medical equipment, sound research equipment, can you use the high sensitivity and complete, brilliant clarity possible under all atmospheric conditions with TELEX Magnetic Receivers?

Should you anticipate such a need, the demonstrated, creative ability of TELEX Engineers can be of invaluable assistance.

TELEX INC.

ELECTRONIC PRODUCTS DIVISION

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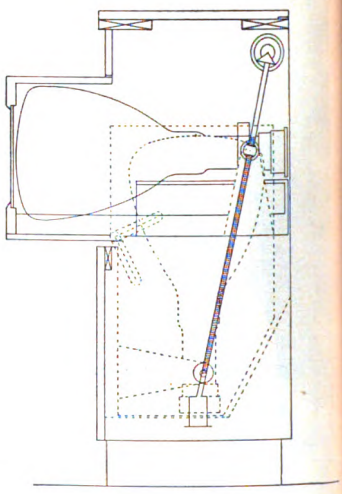
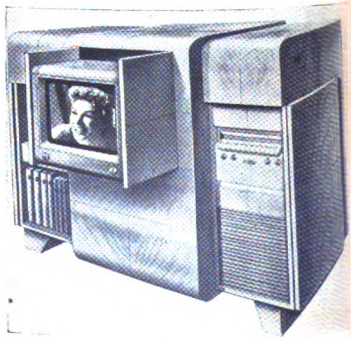
evision, since both the video and audio signals may be transmitted on the same carrier, thus effecting economy in transmitting equipment and the amount of space occupied in the frequency spectrum. Where radio signals are repeated a number of times—as in network broadcasting—or in long-distance radio relaying—efficiency is improved and operating difficulties are minimized with PTM because signal distortion is not cumulative, as it is with conventional methods.

Deloraine, E. M. and Labin, E., Pulse Time Modulation, ELECTRONICS, p. 100, Jan. 1945.

• • •



A retractable c-r tube is featured in the television receiver recently announced by Allen B. DuMont Laboratories. It works as shown above, controlled by pushbutton through a motor drive. Appearance of the 20-in. teleset, a-m/f-m, and phonograph combination is as below. Also shown was a projection model of similar design which threw a 3 by 4 ft picture



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Weight, 23 lbs., 11 oz.

No. 758 1½-volt "A," 90-volt "B" A-B Pack.
Dimensions, 10 11/16" x 6 13/16" x 4 1/8".
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IT WILL be much more than just a "smaller" battery! For the first time, an "Eveready" **"Mini-Max"** B battery will become part of a farm-type radio A-B Pack. As a result, you're going to see a 30% *smaller*, 30% *lighter* "Eveready" "Mini-Max" farm type battery pack *with the same service life* as the conventional pre-war packs, such as our own "Eveready" No. 748 A-B Pack.

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THE ELECTRON ART

Calculation of Distortion Due to Phonograph Needle Wear... 250

Subsurface Prospecting for Hydrocarbon Oil Sands..... 252

Five Radio-Frequency Bridge Circuits..... 264

Calculation of Distortion Due to Phonograph Needle Wear

THE DEGREE OF DISTORTION and loss of highs as a result of phonograph needle wear are discussed in considerable detail by B. B. Bauer of Shure Brothers in the *Journal of the Acoustical Society of America* for April, 1945. Emphasis is placed on the fact that the needle does not long remain spherical but tends to develop "flat" spots at the point of contact with the record groove. Most theoretical papers on this problem have assumed that the needle has a spherical point which does not change with use.

It is pointed out that a spherical point initially penetrates into the surface of a shellac record to a depth of approximately 0.0001 inch under a pickup force of one ounce. After a few revolutions of the record, there is considerable abrasion at the portion which presses most deeply into the record and this tends to even out the spherical surface. Because of the pivoting of the tone arm, the flat exhibits a slight curvature.

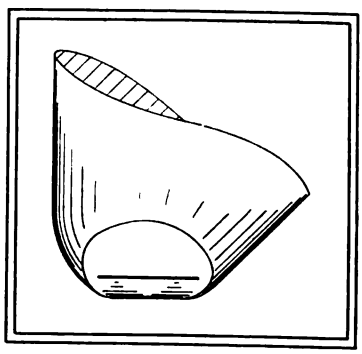

Fig. 1—Side view of worn needle point, showing the flattened portion

Difficulty was had in measuring the size of the flat since there is no sharp line of demarcation between the worn section and the spherical portion. The method finally adopted consisted of directing a distant source of light perpendicularly to the flattened portion and observing the needle tip under a medium power microscope (100 to 200×). Light is reflected from the worn surface as a straight line which is measured using a calibrated eyepiece. The width of the flat can be determined with a precision of 0.0002 to 0.0003 inch. The side view of a typical needle point with a 0.0025-inch flat is shown in Fig. 1.

The size of the flat developed on three needles of different types as a function of the playing time is shown in Fig. 2. Popularly priced 10-inch commercial shellac records and one-ounce pickups were used. It was noted that considerable variation existed within a class because of the use of different alloys, jewels, etc.

Method of Analysis

A technique similar to that used by Pierce and Hunt[1] was used for analysis. In this method, the motion imparted to the needled point by each groove wall separately was studied. The results were then combined later to obtain the complete equation of motion. As a result of mathematical analysis, it was found that distortion attains very large values before there is a substantial reduction in the output level of the fundamental component. This contradicts the common belief that the principal effect of needle wear is a loss in high-frequency response.

Fourier coefficients for calculation of needle wear distortion are given. These indicate that the distortion due to needle wear in a hill-and-dale system is of the same nature as that which occurs at a single side wall. Similarly, the same

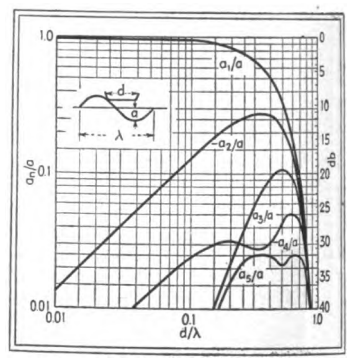

Fig. 3—Fourier coefficients for calculation of distortion due to needle wear

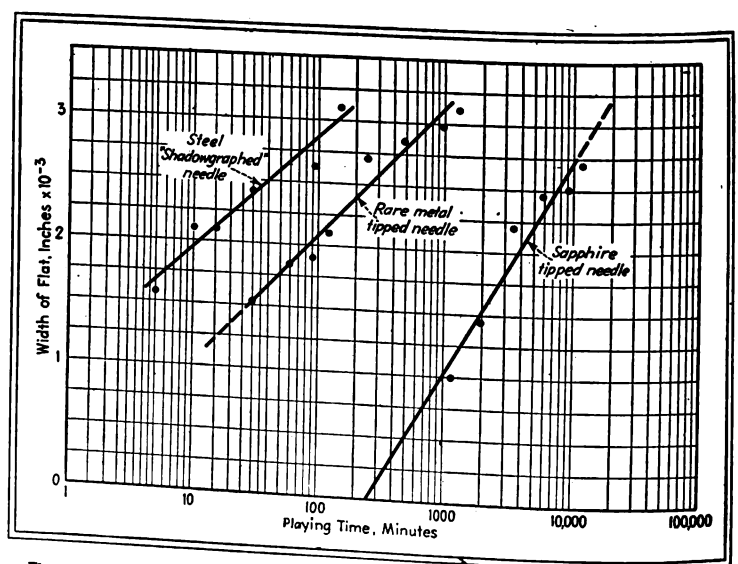

Fig. 2—Needle wear as a function of playing time measured on three different needles

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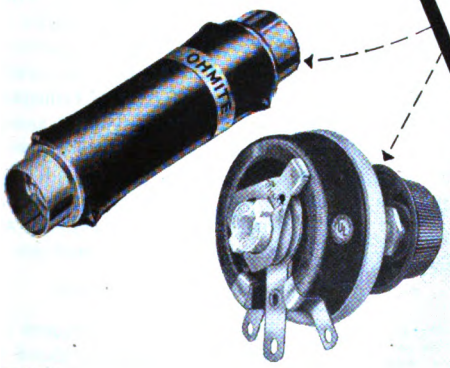

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type of distortion in a lateral system is like that in a single side wall, except that even harmonics tend to cancel out. Such cancellation could not be perfect unless the two needle flats are identical.

Calculations are carried out in some detail using Fig. 3 in estimating distortion. Measured values of distortion compare favorably with those calculated.

• • •

Subsurface Prospecting for Hydrocarbon Oil Sands

AN INSTRUMENT for determining the presence of hydrocarbon oil sands or oil bearing formations by electronic means is the subject of a patent issued to Donald G. Hare of Houston, Texas, and assigned to Texaco Development Corporation.

In the proposed method, fast neutrons are caused to be emitted and passed into the formation around a hole drilled in the earth. Some of the neutrons after being scattered in the formation return to the surveying device to cause an indication of the variation in the types of formation through which the hole is drilled. A source of penetrative gamma rays which may be associated with a neutron source is lowered into the hole and these rays are scattered by the formations through which the hole has been drilled, a certain number of these rays then returning to the instrument.

The instrument is provided with a suitable detector such as a Geiger-Muller counter or ionization chamber. The amount of radiation scattered back to the instrument will vary with the type of formation adjacent to the instrument according to well known physical laws and thus by measurement of the intensity of this scattered radiation, information may be obtained as to the nature of the formations.

Emission Source

The surveying instrument comprises a substantially closed casing which is arranged to be lowered and raised through the hole. The casing contains a suitable source of gamma rays and neutrons such as a tube in which is sealed a mixture of a small amount

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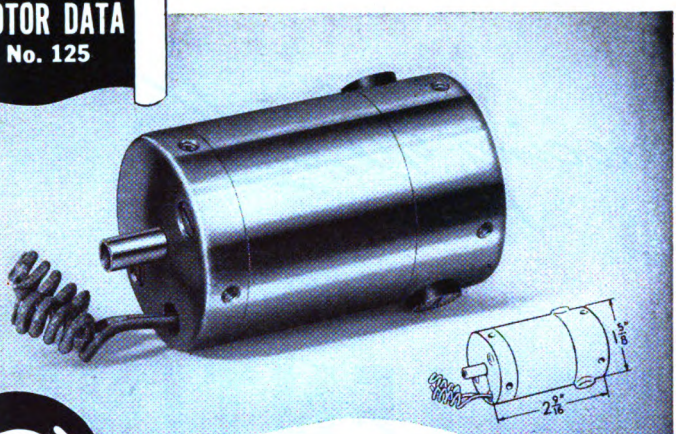

EICOR

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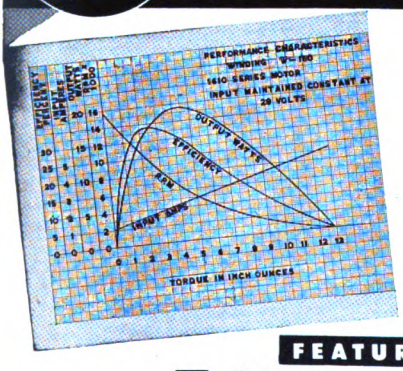
Torque 4.5 in. oz. at 5800 RPM



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Low RF interference	Two precision ball bearings
Armature and field windings	Mica insulated commutator
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1600 FRAME MOTORS		Series	Shunt
Watts Output, Int.	(max.)	22	
Watts Output, Con.	(max.)		5
Torque at 8500 RPM	(in. oz.)	3	
Torque at 5800 RPM	(in. oz.)	4.5	1
Lock Torque	(in. oz.)	12	3
Volts Input	(min.)	5	5
Volts Input	(max.)	32	32
Shaft Diameter	(max.)	.250"	.250"
Temperature Rise		50°C.	40°C.
Weight		12 oz.	12 oz.

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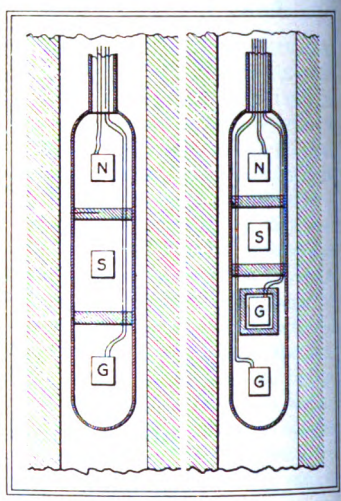
of a radium sulfate or chloride and a considerably larger quantity of finely powdered beryllium metal. A detector for the detection of gamma rays only is also disposed within the casing and is separated from the source by a suitable shield of lead.

The detector used for detecting gamma rays to the exclusion of neutrons may be such a device as a Geiger-Muller tube, operated at a potential sufficiently high so that the electrons emitted by the inter-



Two devices for lowering into bore holes for determining the nature of the surrounding earth formation. *A* source of gamma rays and neutrons, *S*, produces emissions which are picked up by detectors *N* and *G*

action of a gamma quantum with the tube wall will cause the tube to discharge. Within the upper part of the casing is a detector adapted for the detection of neutrons only and this detector is also separated from the source by means of a shield. The shields tend to prevent direct radiation from the source from reaching the two detectors. The shield for preventing neutrons from passing directly from the source to the detector may, if the detector is such as to respond to slow neutrons only, be a sheet of cadmium or other substance or a combination of cadmium and boron having a high capture cross-section for slow neutrons.

If desired to have the detector respond to both fast and slow neu-

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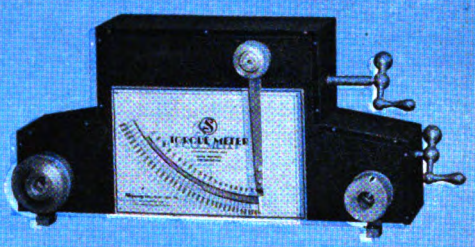

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trons, the shield may consist of 10 to 20 cm of a hydrogenic material such as paraffin, for slowing down the neutrons, followed by a layer of cadmium or other substance as described above. Such a thickness of paraffin will slow down practically all the neutrons to an energy suitable for their capture by a cadmium shield. The detectors may be Geiger-Muller counters, or ionization chambers, and may be connected to suitable amplifiers to actuate indicating or recording instruments at the surface.

Gamma-ray Detector

Since the number of gamma rays scattered per unit volume will depend on certain physical properties such as density and atomic number of the substances making up the formation, by measuring the number of such gamma rays scattered back to the detector we can obtain valuable information concerning the nature of the formation adjacent to the instrument. Thus, as the device is moved along the bore hole from point to point, changes will be noted in the intensity of the gamma rays scattered back to the detector and these changes may be correlated with the types of formations through which the bore hole has been drilled. A continuous survey may be made of a bore hole and, since the gamma rays are little influenced by the presence of iron or steel in the hole, the device can be used with success in the logging of holes containing casing or drill pipe.

Neutron

The neutron detector is included to pick up those neutrons which are scattered and returned to the instrument in a manner similar to that in which the gamma ray detector operates. With this arrangement, additional information may be obtained such as the presence or absence of hydrogenic substances in the structure of the formations. This is particularly true if the detector is capable of differentiating between fast and slow neutrons, thus detecting those which have been slowed down by collision with hydrogen nuclei. Such a detector may be a boron-trifluoride ionization chamber.

A modification of the unit which

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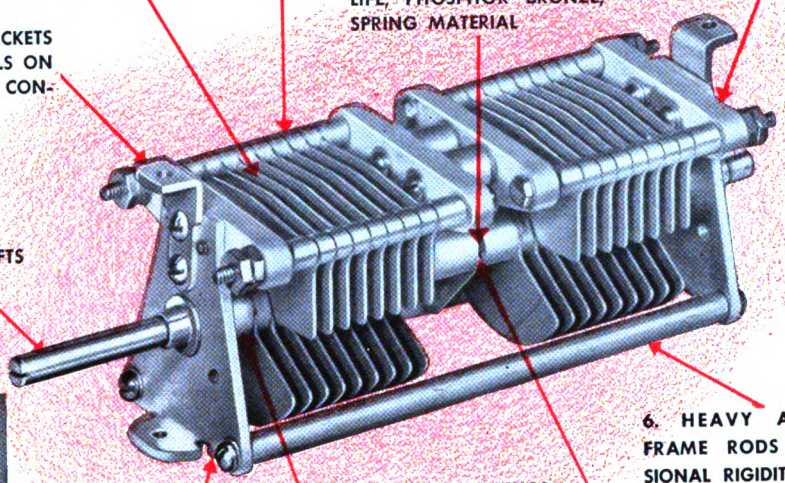

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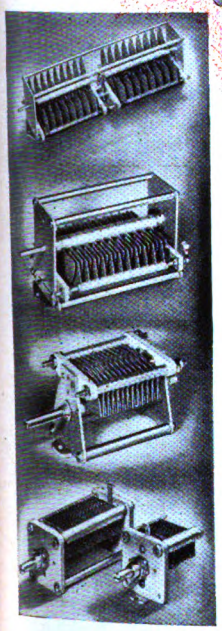

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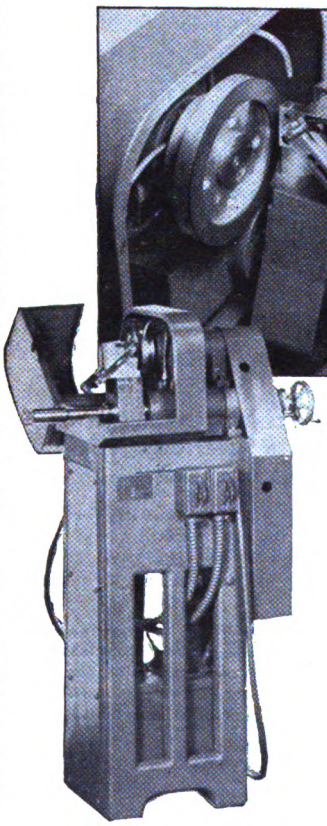

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employs three detectors is also shown in the accompanying illustration. This arrangement is designed for detecting the change in penetrating power or hardness of the gamma radiation caused by scattering in the formation. Two gamma-ray detectors are employed, one being well shielded to provide selective absorpion as a function of wavelength of the radiation while the other is unshielded. The shield around the detector decreases the intensity of the less penetrating gamma radiation and permits the detector to record principally the radiation which has been least affected by the scattering process. Comparison of the intensity registered by the two detectors provides information regarding the scattering processes and thus of the type of formation doing the scattering.

• • •

Five Radio-Frequency Bridge Circuits

THE FOLLOWING SERIES of radio-frequency bridges have been developed by the British Broadcasting Corporation during the past ten years and a more detailed description of them was given by H. L. Kirke, head of the research department, in delivering the chairman's address for 1945 of the IEE radio section. They are all types that have been well proved by long usage in the field and laboratory.

A short-wave admittance bridge is shown in the schematic of Fig. 1. Reactance balance is obtained by

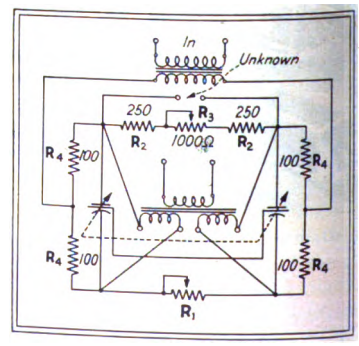

Fig. 1—Short-wave admittance bridge for field use. Resistor R_1 is the standard resistor and resistors R_2 and R_3 are used to balance the maximum value of R_1. Resistors R_4 are the ratio arms of the bridge

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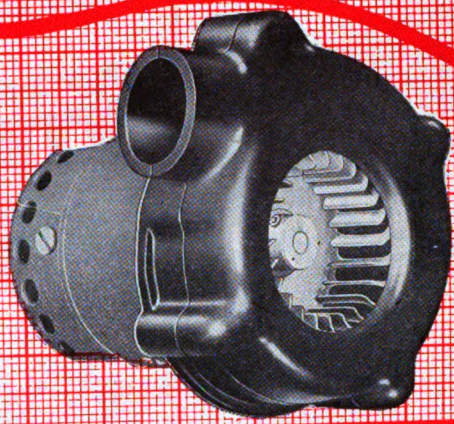
Graph shows . . .
OUR J-31C MOTOR DRIVING A No. 2 BLOWER, WHICH COMPRISES OUR MODEL J-52 BLOWER UNIT

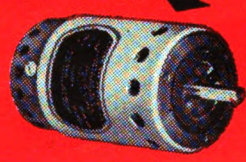


00 600 800 1000 1200 1400 1600 1800

Line Frequency — cycles per second

400 to 1800 cycles
Variable Frequency Induction Motor

MODEL J-31C



This motor operates over entire frequency range of 400 to 1800 cycles with 115 volt supply and 0.3 mfd. condenser When driving Blowers or Fans will deliver 17 to 20 C.F.M.

Dimensions:
Overall Diameter 1 15/16"
Overall Length . . 2 29/32"
Weight . . . . . 16 oz.

The development of this variable frequency motor represents a real advance in the art of motor engineering. It is typical of the abilities of Eastern Air Devices where unusual research, engineering, tool making and production skills combine to build special products for which no specifications exist.

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ARMY E NAVY

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the ganged differential capacitors C and resistance balance by a veriable carbon resistor. Comparison of the unknown quantity and the internal standard is by means of a three-winding, dust-cored transformer. Two of the windings are used differentially to produce a null balance; the third is an output winding for the detector. This bridge is particularly valuable in the field, due to the rapidity with which it can be used, although the accuracy is not of the highest order.

A medium and long-wave admittance bridge is given in Fig. 2. This bridge is somewhat similar to that shown in Fig. 1 but the resistance ratio arms are replaced by

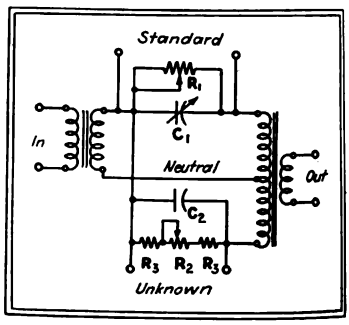

Fig. 2—Medium and long-wave admittance bridge. Capacitor C_1 is the standard and C_2 is a fixed capacitor which is switched in for inductance measurement

the transformer windings used previously for the same purpose. It uses standards consisting of a variable capacitor and a variable resistor in parallel. Normally it measures unbalanced impedances but can handle balanced types when converted to the type of bridge shown in Fig. 1. The change is carried out by means of a switch. Internal standards are provided but external ones can be used.

Multi-Ratio Bridge

A medium and long-wave multiratio admittance bridge is shown in Fig. 3. This form of bridge has been designed for use in the frequency range from 15 kc to 2 Mc and the various ratios are obtained by tapped transformers. As before, a resistor and a capacitor, effec-

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This new and improved Westinghouse porcelain . . . Zircon Prestite : : : is mechanically strong and impervious to moisture. It has a low-loss factor and high resistance to heat shock (see table). Millions of Solder-Seal and Prestite bushing applications are in war service today : : : proving a simpler, quicker, more dependable answer to bushing problems as a result of 15 years of Westinghouse experience and engineering.

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CHARACTERISTICS OF ZIRCON PRESTITE

Property	*Zircon Prestite	High-Tension Porcelain
Specific Gravity	3.68	2.4
Water Absorption, in %	0.00	0.00
Dye Penetration	None	None
**Linear Coeff of Thermal Expansion (20 to 7000 deg C) per deg C	4.9 x 10 $^{-6}$	5.3 x 10 $^{-6}$
Tensile Strength, lb per sq in	12,000	5,000
Compressive Strength, lb per sq in	90,000	48,000
Transverse Strength, lb per sq in	25,000	11,000
Impact Resistance (modified Charpy method) in gm per sq cm	17,800	6,000

*Approved as L-4 material by the Army-Navy Electronics Standards Agency.
**This characteristic gives Zircon Prestite its remarkable thermal shock properties and warrants comparison with other low-loss, high-frequency ceramic materials.

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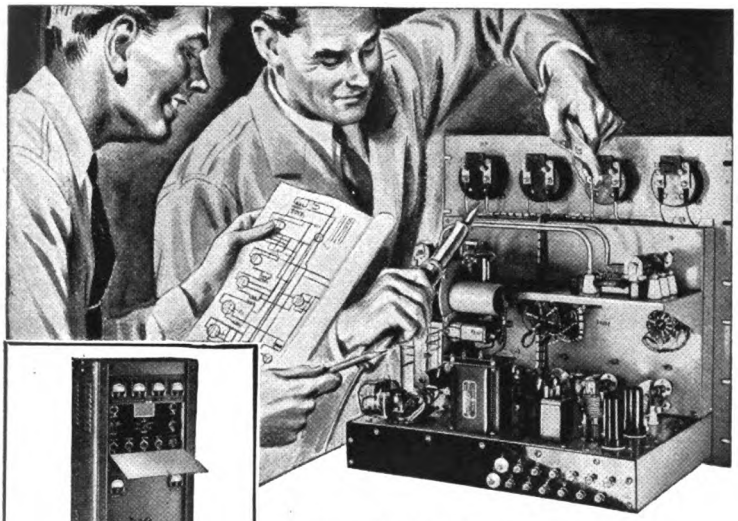

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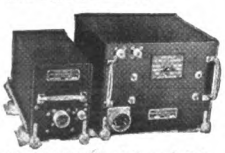
TRANSMITTER-RECEIVERS—*Mobile and Fixed Station Types 2.5—8 Mc.*



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COMMUNICATIONS COMPANY, Inc.

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tively in parallel, form the standard but each can be connected to different transformer taps to provide independent resistance and reactance ratios.

To maintain exact voltage ratio and phase in the standards and unknown values, under different conditions of loading, the leakage reactance of the transformer is minimized by the use of a Mumetal strip wound as a toroid, and also by careful winding.

A radio receiver 2-gang capacitor of 7-250 $\mu\mu$f is used for the standard. It is switched between

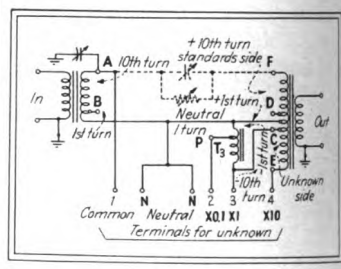

Fig. 3—Tapped transformers are used in this bridge circuit to provide several ranges

taps of the input transformer and taps on the standard side of the output transformer for capacitance measurements, and to one of the taps on the unknown side for inductance measurements.

For resistance balance, a 1000-ohm potential divider (Fig. 4) is connected across appropriate taps

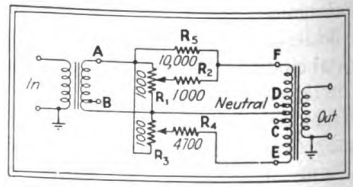

Fig. 4—Resistance balance is obtained by adding R_1 and R_3 to the circuit shown in Fig. 3

of the input transformer and a fixed resistor R_2 from the slider is switched to either tap on the output transformer. The inductance of the potential divider is thus of less importance than if it were used as a variable resistor. The ranges of the bridge are:

Capacitance: 0.01 $\mu\mu$f to 25,000 $\mu\mu$f.

Inductance: Such as will reso-

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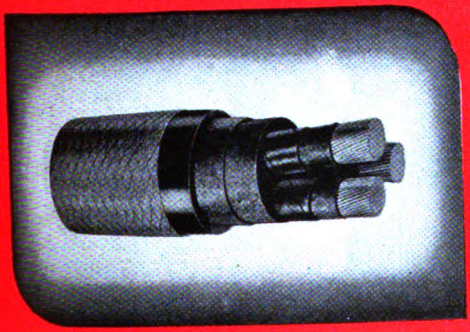
OKONITE "FIRSTS" FOR THE NAVY

- First to offer a corrosion-resistant lead alloy coating for copper conductors ("Okoloy")
- First to develop a method of assembling conductors to increase resistance against twisting ("Unilay")
- First to supply conductors insulated with a non-flammable synthetic dielectric ("Okoseal")
- First to protect conductors with flame-resistant glass fiber insulation ("Okoglass")
- First to manufacture the synthetic impervious sheath for protecting cables ("Okoseal")

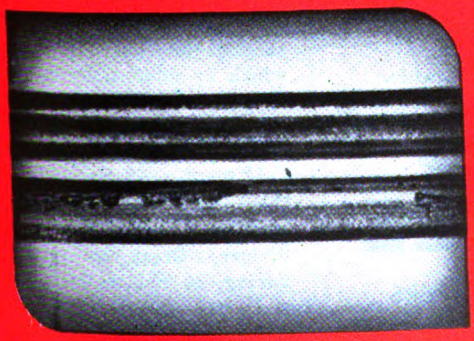
they ALL benefit the ELECTRONICS industry

Meeting Navy demands has been more than a challenging experience to Okonite chemists and research engineers. It has helped to introduce better products of greater value to all industry. Among Okonite's pre-war developments in electric cable and insulated wire are many which have been improved and which have found their greatest usefulness in wartime. Some of them whose service advantages have commercial applications are listed and illustrated. Write for further information on any or all of them or for assistance on any specific problem involving the transmission or distribution of electrical power through insulated wires and cables. The Okonite Company, Passaic, New Jersey.

OKOSEAL as wire insulation is moisture-tight, non-flammable, resistant to chemicals, oils, and ozone.



OKOSEAL as a flexible sheath, in addition to the above advantages, is light in weight and mechanically strong.



OKOLOY affords a corrosion-proof lead alloy conductor coating that outlasts tinning at least 2 to 1. Okoloy (top) is unaffected by immersion.

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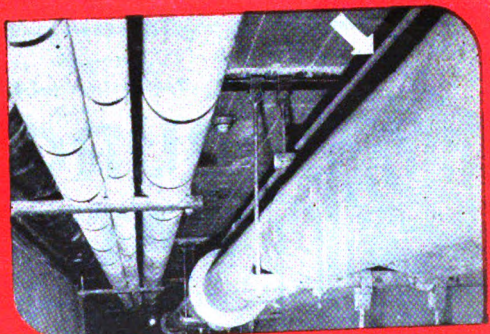
insulated wires and cables



OKOGLASS insulation, which cannot burn or give off flammable gases, protects cables in hot locations, as near steam lines.

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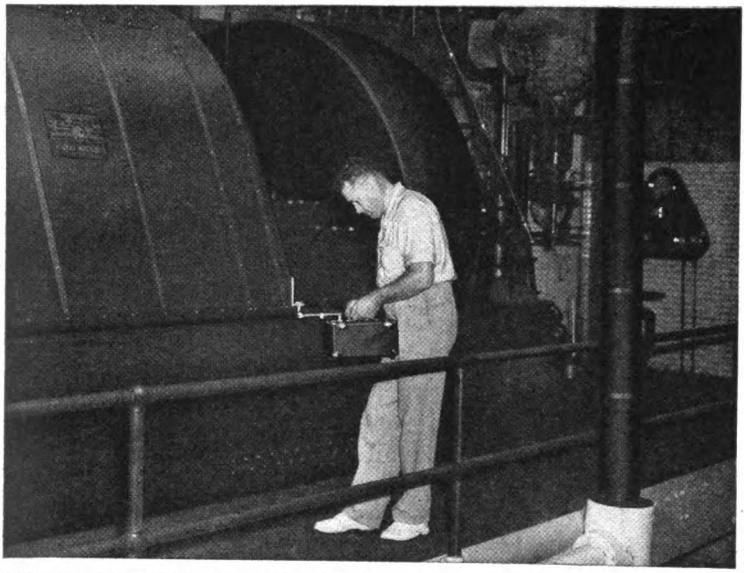
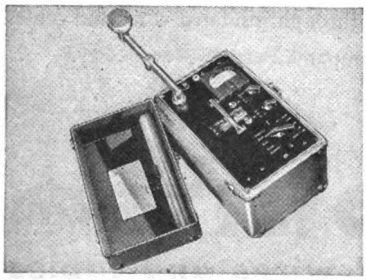
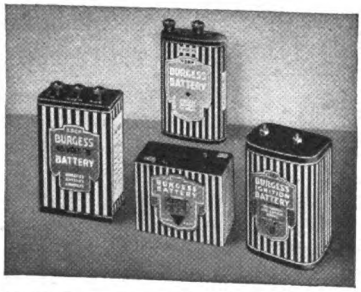
PORTABLE POWER PROBLEMS

THIS MONTH—THE SOUND-LEVEL METER



BURGESS INDUSTRIAL BATTERIES meet every power requirement for the conveniently portable sound-level meter. Used for qualitative measurement of sound, the meter consists essentially of a sound pickup, a special electronic amplifier and an indicating instrument. Burgess Industrial Batteries give dependable, long service life in hundreds of electronic industrial applications—they meet every requirement for test and control instruments.





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nate with the above.

Resistance: 10 ohms to 10 megohms.

V H F Circuit

An ultra-short-wave admittance bridge appears in Fig. 5. In this instrument, the input and output transformers both have a ratio of 3:1, giving a total of 9:1. This ratio enables a capacitor of low inductance to be used as a standard, and the value of resistance is also more convenient. Capacitors C_1 and C_2 are the standards, of 60

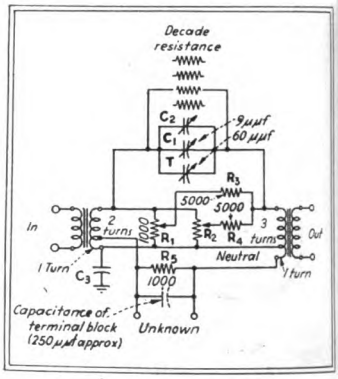

Fig. 5—An accuracy of five percent over a range of frequencies from 100 kc to 100 Mc is claimed for this bridge circuit

and 9 $\mu\mu$f respectively, but the 9-$\mu\mu$f capacitor is calibrated from 0 to 70 $\mu\mu$f (the capacitance which it balances), and the 60-$\mu\mu$f unit is calibrated from 0 to 500 $\mu\mu$f. Owing to the necessity for reducing internal inductance in the bridge, the capacitance of the 60-$\mu\mu$f unit at half scale, plus the zero capacitance of the small capacitor and that of a trimmer, is balanced by the capacitance of about 250 $\mu\mu$f across the unknown terminals, which is obtained by making the leads and the massive terminals in one unit, spaced by a sheet of mica.

Groups of carbon resistors are used for the resistance balance and there is a continuous adjustment of resistance balance with a potential divider. Great care is taken in wiring, to reduce the inductance and stray fields. All leads are of copper tape and external leads are kept very close together.

A 30-ohm carbon resistor is used as the resistance standard, its ends

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being cased in copper to neutralize inductance. It is non-reactive up to 60 Mc.

To measure the internal inductance of the bridge, a measurement is made of an inductance and a resistance in series. This is provided by a single turn of 46 SWG eureka wire on a 3/8 inch former. The inductance can be calculated and the resistance measured on d-c and calculated for high frequencies.

The accuracy of the bridge is not worse than 5 percent and is considered fairly good for the frequencies covered (100 kc to 100 Mc) and for such a simple piece of equipment. Ranges are as follows:

Capacitance—Up to 300 $\mu\mu$f.

Shunt Resistance—10 to 10,000 ohms.

Inductance—Such as will resonate with the above capacitances.

Inductance Measurements

A medium and long-wave low impedance bridge is given in Fig. 6. This bridge covers the frequency range from 100 kc to 2 Mc and is designed particularly for low-

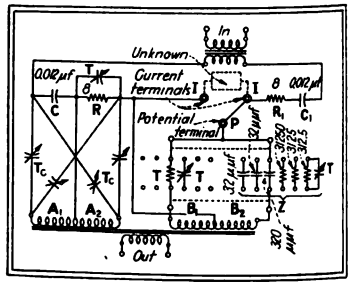

Fig. 6—Low values of inductance as well as the resistive component are measured by this circuit. Capacitance may also be measured by changing the calibration of the dial. Capacitors marked T are trimmer types

inductance measurements. It also measures the resistive component. Capacitance measurements can be made but the dial readings are in reciprocal capacitances.

The method is to determine the potential difference across the unknown impedance and to compare this with the current through it. Independence between the circuits is achieved (like the Kelvin double bridge) and this enables mutual inductance to be measured. It also

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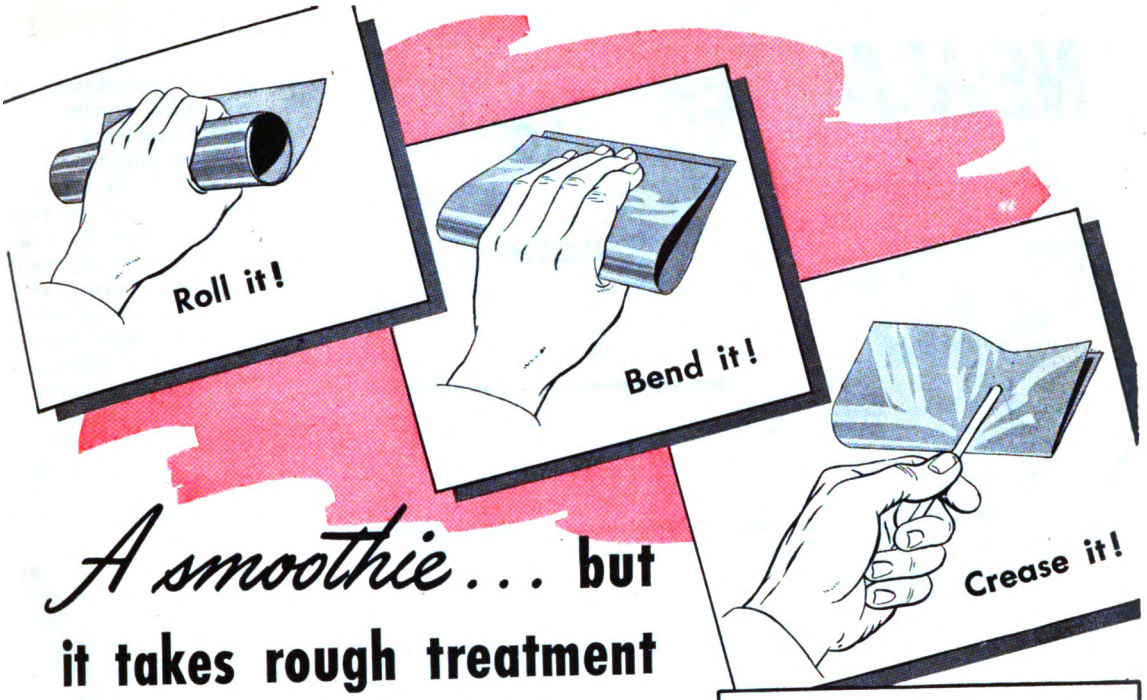

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You can form DOBAR laminated insulation paper into almost any shape without damaging its smooth surface or changing its electrical characteristics. It slides readily into small, confined spaces with minimum pressure and friction, making it quick and easy to handle.

The laminated moisture-barrier of cellulose acetate film increases dielectric strength to 70% better than standard paper, under ordinary conditions. At 85% RH and 85° F., DOBAR tests up to 296% better. Leakage tests under the same conditions show an improvement of 327%. With its high resistance to moisture, solvents, weak acids, mineral oils and similar dangers, DOBAR effectively increases your margin of safety.

These DOBAR advantages apply wherever you use insulation paper. Send for samples to test on your own applications.

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1. High dielectric strength
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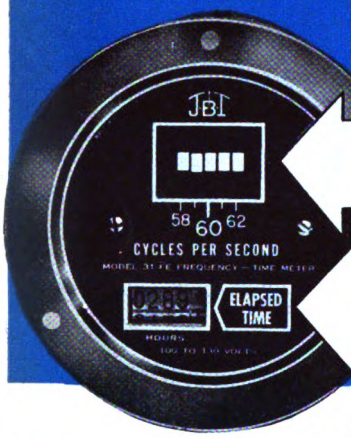
NEW METER Indicates BOTH



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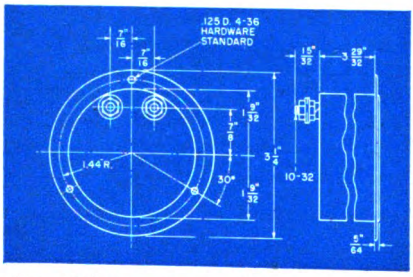

Size...3¼" flange diameter. Black metal case for flush-panel mounting. 5 reeds...58-62 cycle range. Accuracy ... ± 0.3%. Power consumption ... 3 watts, 110 volt operation. Weight...1.3 lbs. Also made for 59-61, 48-52, and 49-51 cycle ranges.

This combination running time and frequency meter is just one of the variations J-B-T has pioneered for specific field and laboratory use in measuring speed, temperature and frequency. This and 17 other interesting applications are illustrated in a new bulletin, now ready.

They may suggest ways to attack your own problems...through use of J-B-T's wide engineering "know how," laboratory set-up and production capacity. Ask for Bulletin VF 43-IC.

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means that the internal inductance of the instrument is unimportant.

An input transformer supplies current to pass through the unknown impedance, via a 0.125-μf fixed capacitor C and an 8-ohm fixed resistor R. Capacitor C_1 and resistor R_1 balance the circuit with respect to ground. The drop across C is applied to a 400-$\mu\mu$f variable capacitor in series with one winding of a summation transformer, and the drop across R is applied to a second 400-$\mu\mu$f variable capacitor and another winding on the transformer. The resultant core flux is therefore a measure of the amplitude and phase of the current through C and R.

A third winding on the transformer takes the drop across the unknown impedance, via a fixed resistor Z, producing a current proportional to and in phase with the voltage across the unknown. When the two variable capacitors are adjusted so that the amplitude and phase of the currents in the transformer windings produce a flux, equal in amplitude and opposite in phase to the flux from the third winding, the resultant flux will be zero and a null balance will be obtained.

The values of the two variable capacitors and the resistance of Z

• • •

SOUND TRUCK

The psychological warfare branch of the British Army used this camouflaged truck to make announcements in German and Polish to the enemy. Hung in trees, the speakers called upon soldiers to surrender

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New Formica Grades

PROGRESS has recently provided new resins and new fibre bases that have greatly increased the heat resistance of insulating grades of Formica. They will take without injury about 25 percent higher temperatures.

An example of this improvement is FF-55, produced to conform to Navy Grade GMG, made with a glass fibre base and melamine resins. It withstands 440 degrees Fahrenheit for a short period, and 390 degrees continuously.

In this same material Arc resistance reaches a new level — by ASTM test D495-42, it is rated at 185 seconds.

The material is strong, and can, therefore, be used to take structural stresses when the design makes that desirable. Test figures: Tensile strength 25,000 P.S.I.; Compressive strength (flatwise) 90,000 p.s.i.; Flexural Strength (flatwise) 30,000 p.s.i.; Modulus of Elasticity in bending 3,000,000 p.s.i.; Izod impact, 12 ft. lbs. per inch of notch.

This is a new combination of useful qualities, not previously available in one material. Unlike some materials which possess some of these characteristics, the material can be easily punched and machined. It is suitable for rapid fabrication by production methods.

THE FORMICA INSULATION COMPANY, 4661 SPRING GROVE AVENUE, CINTI. 32, O.

FORMICA

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will be a measure of the reactance and resistance of the unknown impedance.

Capacitance Measurements

To measure capacitance, the resistor Z is replaced by a fixed capacitor, which interchanges the dial indications of the two variable capacitors. The one which indicated resistance then gives reciprocal capacitance and that which indicated inductance then reads resistance.

Range of the bridge is dependent on the value of the resistor Z (or the capacitor which replaces it), according to the following table:

Standard Z	Range of measurement
312.5 ohms resistance	0–10 ohms; 0–1 μh
3,125 ohms resistance	0–100 ohms; 0–10 μh
31,250 ohms resistance	0–1,000 ohms; 0–100 μh
320 $\mu\mu$f	0–10 ohms; 10,000 $\mu\mu$f to infinity
32 $\mu\mu$f	0–100 ohms; 1,000 $\mu\mu$f to infinity
3.2$\mu\mu$f	0–1,000 ohms; 100 $\mu\mu$f to infinity

Accuracy of measurement is reasonably high for most laboratory work and the bridge is easy to use. For high-Q circuits, however, the accuracy of resistance measurement is not good, since the range of resistance measured is not independent of the range of inductance measured. This difficulty can be overcome.

• • •

TESTING WIRE

The insulating value of the enamel coating on fine wire produced at the Dobbs Ferry plant of North American Phillips is checked on this instrument

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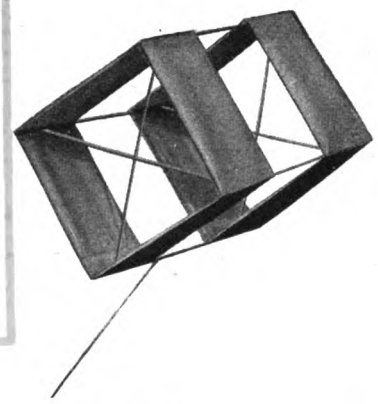
THEIR FAVORITE BLONDE



THIS IS THE GIBSON GIRL* with her hourglass shape and a bright yellow dress . . . the magic emergency radio transmitter which automatically sends out S-O-S signals by merely turning the hand crank. ☆ Now carried on overwater flights by most military planes, Gibson Girls have snatched back to life many American, Canadian and British crews forced down at sea. ☆ The hand crank generates sufficient power to transmit signals over a 100,000 square mile area, and to light a brilliant signal light. Manual keying on radio transmission is available. The unit is equipped with parachute for release from a rescue plane or before a crash landing. ☆ More than 60,000 Gibson Girls have been produced by Pacific Division since they were developed by this company before Pearl Harbor. Such outstanding radio developments as this demonstrate Pacific Division's unique ability to successfully solve new radio problems. Our engineers—now specializing in VHF communications systems—are available to assist you with your radio problems.

*Trade Mark Reg. U.S. Pat. Off.

All rescued airmen become members of the most exclusive fraternity in the world—the Order of Gibson Girls. They receive this certificate and a gold lapel pin. If you have been rescued or know someone who has, write today to the Order of Gibson Girls, North Hollywood, California, for membership.

Pacific Division
Bendix Aviation Corporation
NORTH HOLLYWOOD 7, CALIF.

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NEWS OF THE INDUSTRY

Alien patents; fm-television truce; therapeutic music; fluorescent fungicides; Washington and FCC news; business and personnel activities

FCC Releases Proposed Allocations Below 25,000 Kc

THE PROPOSED ALLOCATION of frequencies to non-government radio services operating in the portion of the radio spectrum below 25,000 kilocycles, as released May 21, is given in the table below. After all oral arguments have been heard, starting in June, the Commission will issue a final allocations report covering non-governmental radio services in this portion of the spectrum.

Highlights of the FCC proposals include addition of another radio channel to the lower end of the present standard broadcast band, at 540 kc; provision of 120 radio channels, some of which will be available to the United States, for direct international short-wave broadcasting; allocation of frequencies for use by radio amateurs and others during

PROPOSED FCC ALLOCATIONS BELOW 25,000 KILOCYCLES

Freq. in kc	United States Allocations	Proposed International Allocation
Up to ~100	Fixed	Fixed
100–160	Coastal, marine relay, ship, mobile press, fixed Alaskan	(a) Fixed (b) Maritime mobile
160–200	Fixed (1)	Fixed (1)
200–280	Air navigation aids	Air navigation aids
280–320	Maritime beacons	Maritime beacons
320–415	Air navigation aids	Air navigation aids
415–490	Coastal, marine relay, ship	Maritime mobile (telegraphy)
490–510	Mobile (distress & calling freq. 500 kc)	Mobile (distress & calling freq. 500 kc)
510–535	Mobile (telegraphy) (2)	Mobile (telegraphy) (2)
535–1605	Broadcasting (non-gov.) (3)	Broadcasting (3)
1605–1800	Police, aviation, relay broadcast, special, Alaskan, disaster communication including amateur disaster networks	Fixed, mobile
1800–2000	Navigation aids	Navigation aids
2000–2050	Government (4)	Fixed, mobile (4)
2050–2065	Ship telegraph	Maritime mobile
2065–2075	Mobile (distress and calling freq. 2070 kc) (5)	Mobile (distress & calling freq. 2070 kc) (5)
2075–2100	Ship telegraph	Maritime mobile
2100–2250	Ship telephone, relay broadcast	Mobile
2250–2300	Police point-to-point, ship telephone, aviation, special, relay broadcast	Fixed, mobile
2300–2350	Coastal telegraph, marine relay	Maritime mobile
2350–2495	Police, ship telephone, Alaskan	Fixed, mobile
2495–2505	Government	Standard freq. broadcast on 2500 kc
2505–2700	Coastal harbor telephone, Alaskan	Mobile
2700–2850	Fixed, maritime mobile telephone, police point-to-point, special emergency, relay broadcast, Alaskan	Fixed, mobile
2850–3125	Aeronautical mobile (6)	Aeronautical mobile (6)
3125–3200	Aeronautical fixed (7)	Aeronautical fixed (7)
3200–3330	Government (8)	Aeronautical mobile (8)
3330–3450	Forestry (9)	Mobile, except maritime and aeronautical (9)
3450–3500	Government	Fixed, and mobile except maritime
3500–4000	Amateur	Amateur
4000–4100	Fixed, except aeronautical fixed	Fixed, except aeronautical fixed
4100–4135	Coastal, marine relay, ship	Maritime mobile
4135–4145	Mobile (distress and calling freq. 4140 kc) (5)	Mobile (distress and calling freq. 4140 kc) (5)
4145–4500	Coastal, marine relay, ship, mobile press	Maritime mobile
4500–4890	Fixed, aero. fixed, coastal telephone, Alaskan	Fixed, mobile except aero. (10)
4890–4990	Government (8)	Aeronautical mobile (8)
4990–5010	Government	Std. freq. broadcast on 5000 kc
5010–5300	Fixed, aero. fixed	Fixed
5300–5500	Fixed, aero. fixed, Alaskan	(a) Fixed, and mobile except aero. & maritime
5500–5800	Aeronautical mobile (6)	Aeronautical mobile (6)
5800–6000	Fixed, aero. fixed	Fixed
6000–6200	International broadcast	International broadcast
6200–6300	Coastal, marine relay, ship	Maritime mobile
6300–6450	Fixed, aero. fixed	Fixed
6450–6600	Aeronautical mobile (6)	Aeronautical mobile (6)
6600–6900	Fixed, aero. fixed	Fixed
6900–7000	Government (8)	Aeronautical mobile (8)
7000–7300	Amateur	Amateur
7300–8200	Fixed, aero. fixed, Alaskan	Fixed
8200–8275	Coastal, marine relay, ship	Maritime mobile
8275–8285	Mobile (distress and calling freq. 8280 kc) (5)	Mobile (distress and calling freq. 8280 kc) (5)
8285–8700	Coastal, marine relay, ship, mobile press	Maritime mobile
8700–8900	Aeronautical mobile (6)	Aeronautical mobile (6)
8900–9000	Fixed, aero. fixed, coastal telephone	Fixed, maritime mobile (10
9000–9500	Fixed, aero. fixed	Fixed
9500–9700	International broadcast	International broadcast
9700–9990	Fixed, aero. fixed	Fixed
9990–10010	Government	Standard freq. broadcast on 10000 kc
10010–10200	Government (8)	Aeronautical mobile (8)
10200–11300	Fixed, aero. fixed	Fixed
11300–11500	Aeronautical mobile (6)	Aeronautical mobile (6)
11500–11700	Fixed, aero. fixed	Fixed
11700–11900	International broadcast	International broadcast
11900–12300	Fixed, aero. fixed	Fixed
12300–12415	Coastal, marine relay, ship	Maritime mobile
12415–12425	Mobile 12420 kc (5)	Mobile (calling freq. 12420 kc)
12425–12950	Coastal, marine relay, ship, mobile press	Maritime mobile
12950–13050	Government (8)	Aero. mobile (8)
13050–13250	Fixed, aero. fixed	Fixed
13250–13350	Fixed, aero. fixed, coastal telephone	Fixed, maritime mobile (10)
13350–14000	Fixed, aero. fixed (11)	Fixed (11)
14000–14400	Amateur	Amateur
14400–14985	Fixed, aero. fixed	Fixed
14985–15015	Government	Standard freq. broadcast on 15000 kc
15015–15100	Government (8)	Aero. mobile (8)
15100–15300	International broadcast	International broadcast
15300–16400	Fixed, aero. fixed	Fixed
16400–16555	Coastal, marine relay, ship, mobile press, aeronautical	Mobile
16555–16565	Mobile (calling freq. 16560) (12)	Mobile (calling freq. 16560 kc) (12)
16565–17100	Coastal, marine relay, ship, mobile press, aero.	Mobile
17100–17600	Fixed, aero. fixed	Fixed
17600–17700	Fixed, aero. fixed, coastal telephone	Fixed, maritime mobile (10)
17700–17900	International broadcast	International broadcast
17900–19985	Fixed, aero. fixed	Fixed
19985–20015	Government	Standard freq. broadcast on 20000 kc
20015–20500	Fixed, aero. fixed	Fixed
20500–21000	Fixed, aero fixed, coastal, marine relay, ship, mobile press, aeronautical	Fixed, mobile
21000–21500	Amateur	Amateur
21500–21700	International broadcast	International broadcast
21700–24985	Fixed, aero. fixed	Fixed
24985–25015	Government	Standard freq. broadcast on 25000 kc

(1) Aero. fixed shall have priority in the polar regions.
(2) Not open to public correspondence in the American region.
(3) Lowest and highest assignable frequencies are 540 and 1600 kc.
(4) 500 watts peak power limit for both fixed and mobile.
(5) Calling limited to telegraphy.
(6) Frequencies within these bands are reserved primarily for long-distance overseas air routes and only where the use of frequencies above 30 Mc is impracticable.
(7) Frequencies within this band are reserved for fixed circuits associated primarily with long-distance overseas air routes where other facilities are not available or are impracticable.
(8) Not available to civil aviation.
(9) Power limited to 200 watts peak.
(10) Maritime mobile limited to coastal telephone stations.
(11) 18660 kc is for industrial, scientific and medical. All emissions must be kept within the band 18652.5 to 18667.5 kc.
(12) Limited to telegraphy.

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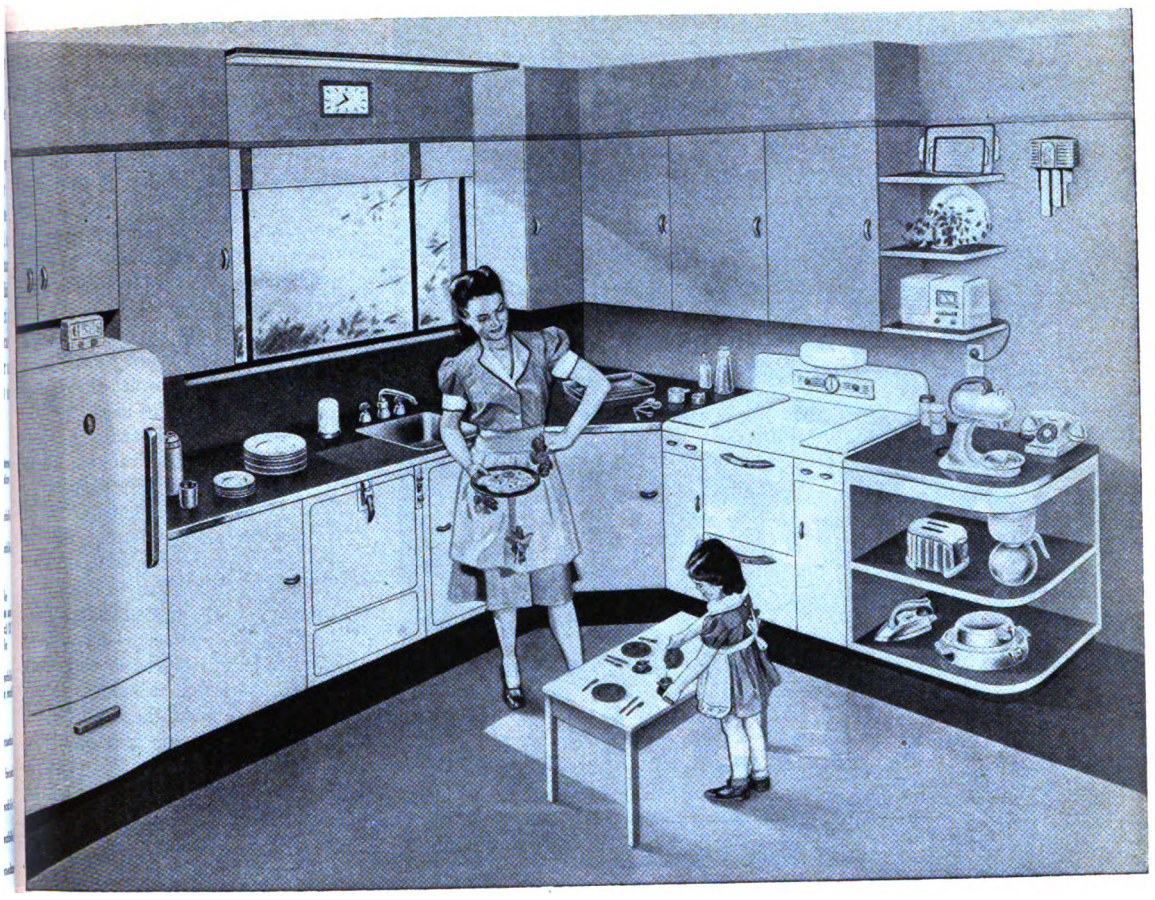

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The plastics kitchen of tomorrow, with its widespread use of Plaskon materials, is but one indication of the versatility of these modern products of industrial research. Plaskon resins offer you exceptional manufacturing and sales advantages in product development. Our experienced field men will gladly help develop your plans.

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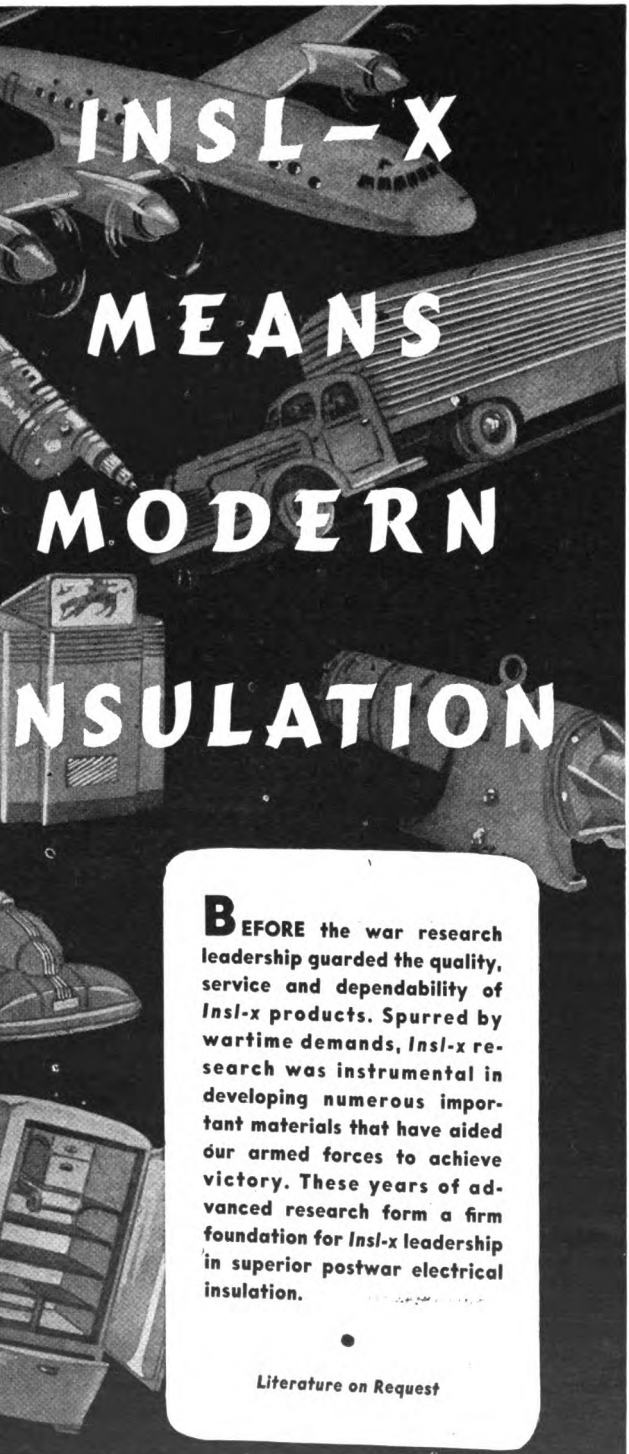

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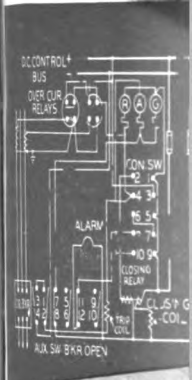
times of disaster, such as floods, earthquakes, hurricanes, etc.; increased emphasis on the requirements of aviation radio communications, including navigational aids, after the war; and establishment of a greater number of SOS frequencies for use by aircraft and small surface craft in distress and to provide more reliable coverage over long distances on radio distress calls.

As the commission points out, the radio spectrum below 25,000 kilocycles is so overcrowded that it has been impossible to meet the requirements of all radio services operating in these ranges. However, the FCC has attempted to make an equitable distribution of frequencies among the various services. Wherever possible, radio services are expected to move into the very high and ultrahigh portions of the spectrum and to take advantage of improved equipment and transmission techniques to enable them to make the most efficient use of the spectrum space available to them.

No decision has yet been made as to the number of new stations the new 540-kc broadcast band channel will accommodate or as to whether the channel will be used by local, regional or clear-channel broadcast stations. It is believed that possible interference with auto alarms on the 500-kc distress frequency can be solved by assigning 540 kc for use at appropriate geographical locations and by limiting the intensity of the signals in coastal areas. (There are now 928 standard stations broadcasting and 23 others under construction. The FCC has in its pending files approximately 180 applications to build new standard stations when manpower and materials again become available for civilian radio construction.) About 54 percent of the present receiving sets will be able to receive programs from stations operating on the 540-kc frequency. However, the channel including 540 kc is now used by the government and it is not known how soon it can be made available to broadcasters.

Six bands of frequencies, involving a total of 120 channels below 25,000 kc, are set aside for direct international broadcasting on a worldwide basis.

The bands 3500 to 4000, 7000 to



ROTARY SWITCH APPLICATIONS
Ammeter 4
A. C. Voltmeter 13
D. C. Voltmeter 9
Frequency Meter 1
Wattmeter 2
Power Factor Meter 2
Temperature Indicator 2
Synchronizing 8

CONTROL SWITCH
Circuit Breaker Control 6
Motor Control
Governor Speed and Rheostat Control

TRANSFER SWITCH
Single Pole
Two Pole
Three Pole
Four Pole
Five Pole
Six Pole

ROLL
Canadian Plant:
STANDARD AND
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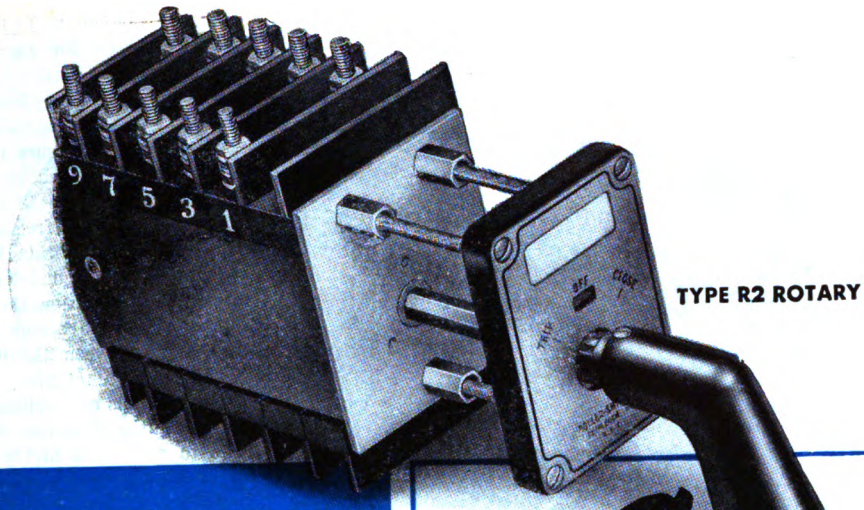
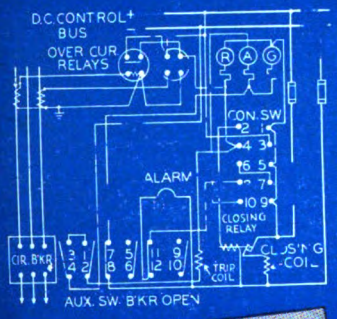


TYPE R2 ROTARY SWITCH



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ROTARY SWITCH APPLICATIONS

Ammeter	4
A. C. Voltmeter	13
D. C. Voltmeter	9
Frequency Meter	1
Wattmeter	2
Power Factor Meter	2
Temperature Indicator	2
Synchronizing	8

CONTROL SWITCH

Circuit Breaker Control	6
Motor Control	1
Governor Speed and Rheostat Control	2

TRANSFER SWITCH

Single Pole	12
Two Pole	14
Three Pole	5
Four Pole	3
Five Pole	1
Six Pole	3

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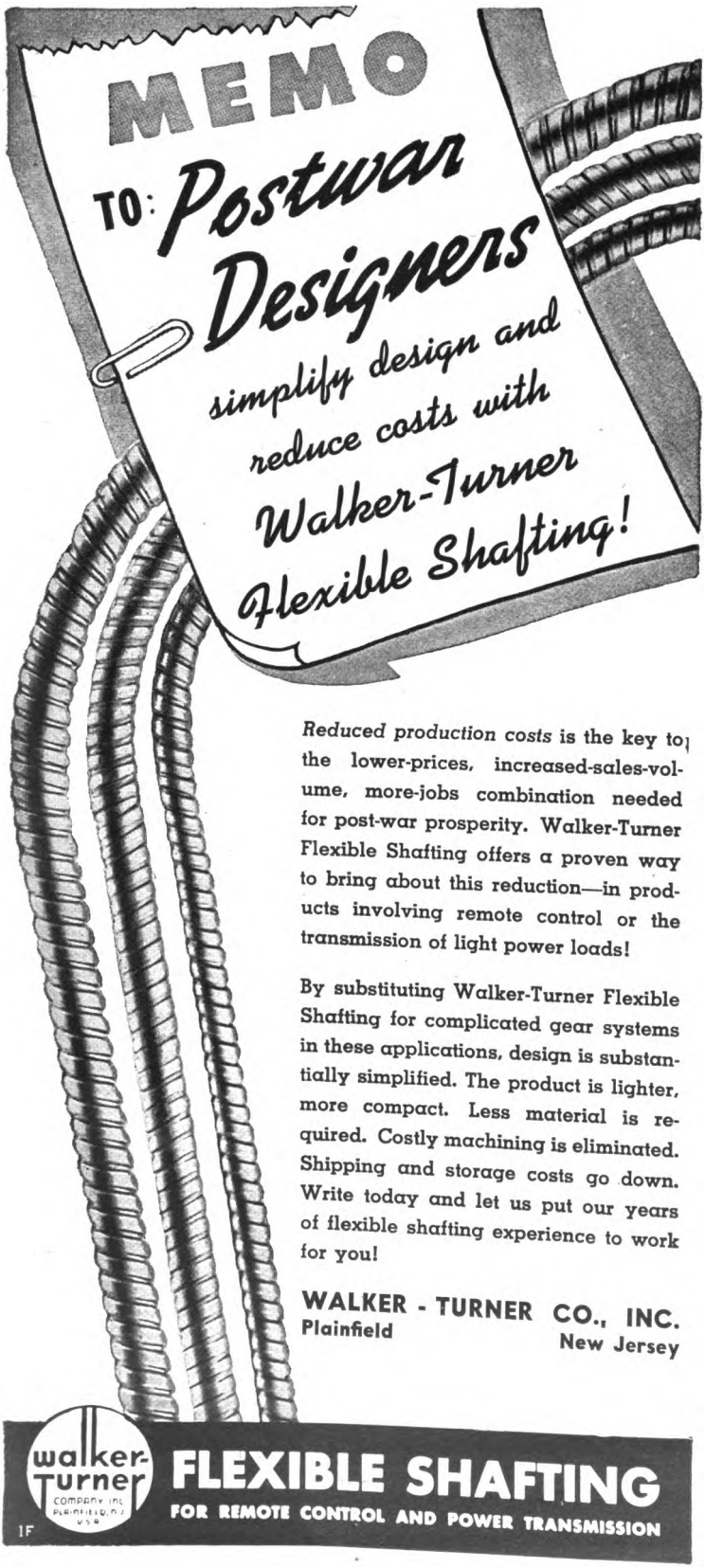

7300, and 14,000 to 14,400 kc are being retained for amateur use. The 300-kc wide band between 1[illegible] and 2050 kc is being deleted. In lieu thereof, the Commission is making provision for amateurs to operate a disaster communications network in the band 1605 to 1800 kc. The exact width of this frequency band and its location within the range 1605 to 1800 kc is undetermined at this time. In addition, the Commission proposes to assign a 500-kc wide band between 21,000 and 21,500 kc to the amateurs.

Six channels are included for use by the National Bureau of Standards to provide a highly accurate standard for the measurement of frequencies, and for the transmission of time signals, to be used by scientists, observatories and radio station operators throughout the world to calibrate their equipment.

The Commission is not making specific proposals regarding channel widths for stations in the fixed public services at this time. However, in view of the urgent requirement for conservation of frequencies, the Commission will expect licensees to avail themselves of the latest technical improvements looking toward early realization of the use of 2.5 kc, or less, per telegraph communication channel and not more than 5 kc per telephone or facsimile channel. This objective is believed to be reasonable since it is expected that, of necessity, use of such technical improvements will be adopted generally on a worldwide basis.

Total Number of Channels

A comparison between the total number of channels requested, the total currently assigned and the total proposed, cannot be made since (1) no decision has been made as to channel widths; (2) the number of channels to be used by aeronautical and government fixed services cannot be determined at this time; (3) the assignments at the time of the hearing included shared frequencies which are regularly assigned to other services such as coastal harbor and coastal telephone; and (4) the channel requirements of other nations throughout the world are not known.

For the fixed public services, the Commission is of the opinion that

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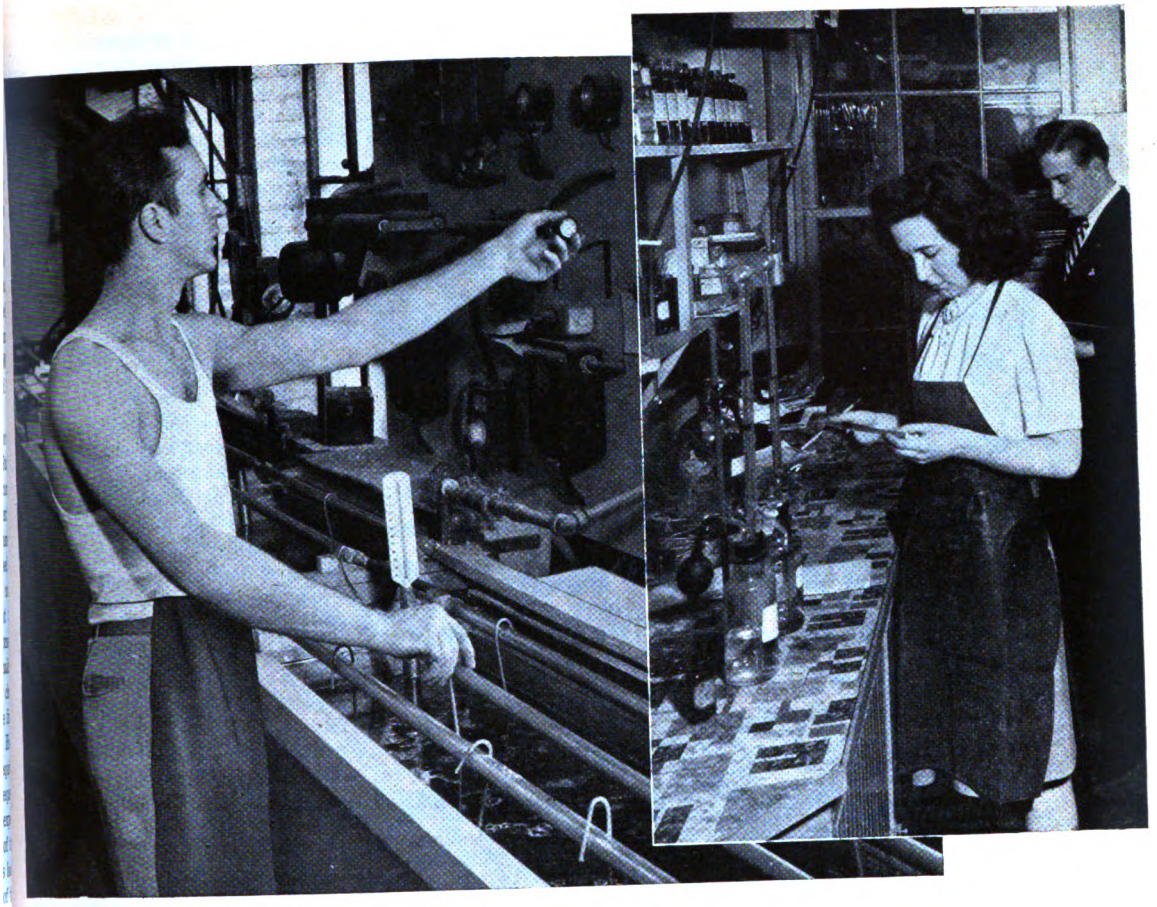

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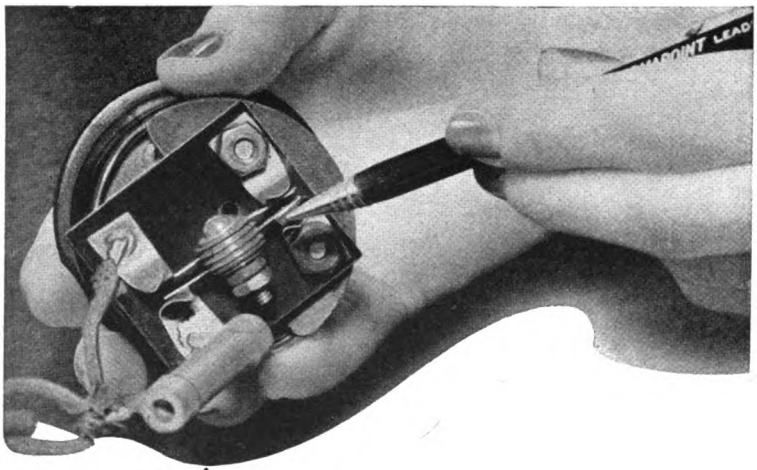

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only through a properly organized system of assigning frequencies, by geographical zones throughout the world, will it be possible to accommodate the post-war requirements of all nations. Under such a zoning plan, a given frequency may be employed in as many as three or more different locations in the world during a period of 24 hours. Such a plan will have the practical effect of increasing the number of channels available to each nation, a consideration of the highest importance when it is realized that many countries will use radio transmission in a post-war era to a far greater extent than they have in the past. The Commission will exert every effort to make such an organized system of assigning frequencies possible.

The provision of shipboard radio direction-finding facilities and a comprehensive maritime beacon system has largely obviated the necessity for shore-based direction finders and has resulted in a decline in their use. For these reasons, it is not proposed to continue the allocation of 375 kc for shore-based radio direction-finding systems.

It is proposed, in view of the improvements in ship station receiver selectivity and transmitter frequency stability, to reduce the guard bands for the 500-kc international distress and calling frequency from 15 to 10 kilocycles.

It is proposed to designate the frequencies 2070, 4140, and 8280 kilocycles as additional international distress and calling frequencies (telegraphy) to facilitate communication between stations engaging in air-sea rescue operations.

Aeronautical Outlook

The requests of civil aviation for radio-frequency bands below 25 megacycles can not be granted in full without seriously affecting the minimum requirements of other services. It is evident that means must be found by which the spectrum space requested can be reduced. This may be accomplished in only one way, namely, by obtaining the most efficient use of the spectrum available to that service. This may be accomplished in several ways: (1) Employ the narrowest band of emission that will satisfactorily transmit the desired intelligence most economically from

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Let us help you on Radio Phones and related parts on a sub-contract basis. Your assignment handled with care, speed, and skill.

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WM. J. MURDOCK CO.
180 Carter St., Chelsea 50, Mass.

the standpoint of spectrum utilization; (2) Restrict air-ground-air communications and inter-aircraft communications to those pertaining exclusively to the necessities of air navigation and to emergencies involving the safety of life and property; (3) Restrict operating power to the minimum required for satisfactory communications in order to permit duplication of frequencies with a minimum geographical separation; (4) Consolidate all international radio communication facilities under one operating agency; (5) Assign frequencies on an area basis instead of a route basis; (6) Employ the very high frequency spectrum for all communication with aircraft flying over land, and restrict frequencies below 25 megacycles to communication with aircraft flying international overseas routes only; (7) Employ radio only where other satisfactory means of communication cannot be utilized.

Bands for aids to air navigation are being assigned for government use substantially in compliance with the request of the RTPB. The one slight change made is that where RTPB requested 200 to 285 kilocycles, the allocation is 200 to 280 kilocycles. In addition, the band 1800-2000 kilocycles is proposed for navigation aids although not requested by RTPB.

Alien Patents

PATENTS FORMERLY owned by aliens and seized by the United States government for uses that will benefit the nation in general and assist in the war effort in particular are vested in and on file at the Office of the Alien Property Custodian.

Enemy patents not already exclusively licensed to American interests prior to vesting are available to United States citizens under non-exclusive, royalty-free licensing for the remaining life of the patent. Patents from nationals of enemy-occupied countries are similarly available, but carry a reasonable royalty payable to the Custodian. If there is a return of patents to former owners in enemy occupied countries, the licenses will continue valid at the same royalty, unless a former owner is dissatisfied with the rate. In this case the right is reserved for him to negotiate with

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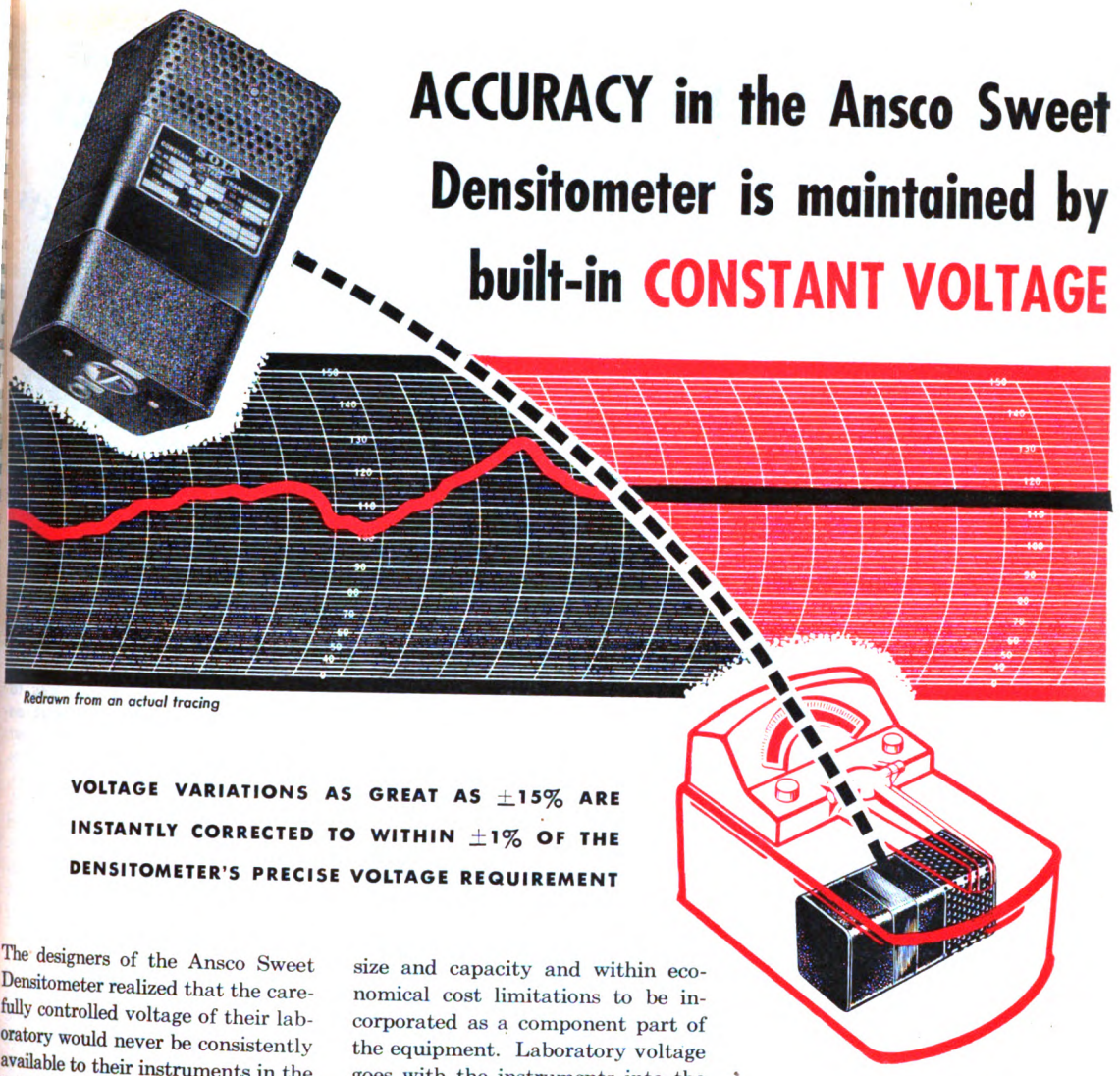
ACCURACY in the Ansco Sweet Densitometer is maintained by built-in CONSTANT VOLTAGE



Redrawn from an actual tracing

VOLTAGE VARIATIONS AS GREAT AS ±15% ARE INSTANTLY CORRECTED TO WITHIN ±1% OF THE DENSITOMETER'S PRECISE VOLTAGE REQUIREMENT

The designers of the Ansco Sweet Densitometer realized that the carefully controlled voltage of their laboratory would never be consistently available to their instruments in the field. Yet the operating voltage must be maintained within an allowable tolerance of ±1% of rated requirements if instant and accurate answers were to be obtained in the study of the sensitometric problems for which it was designed.

In consultation with SOLA engineers a SOLA Constant Voltage Transformer was designed in correct size and capacity and within economical cost limitations to be incorporated as a component part of the equipment. Laboratory voltage goes with the instruments into the field.

The same problem confronts *all* designers of electronic instruments or electrically operated equipment. And the same practical solution so successfully employed in the Ansco Sweet Densitometer and many other similar instruments and devices is available—a SOLA Constant Voltage Transformer as a built-in component.

For the operation of precision instruments and equipment already in use, SOLA Constant Voltage Transformers are available in standard units in capacities from 10Va to 15KVA. Special units can be economically designed for any built-in application. Consultation *now* with SOLA engineers will provide a satisfactory solution for your problem.

Constant Voltage Transformers SOLA

To Manufacturers:
Built-in voltage control guarantees the voltage called for on your label. Consult our engineers on details of design specifications.
Ask for Bulletin DCV-102

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • Door Bells and Chimes • etc. SOLA ELECTRIC CO., 2525 Clybourn Ave., Chicago 14, Ill.

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With DI-ACRO Benders

The DI-ACRO Bender makes perfectly centered eyes from rod or strip stock at high hourly production rates. Both eyes and centering bend are formed with one operation. Any size eye may be formed within capacity of bender and ductile limits of material.

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ONE easy, practical way to speed up development work on your new units, is to turn over your Terminal and Lug problems to Sherman electrical engineers. You'll find that Sherman experience and "know-how" combined with the extensive Sherman production facilities can be extremely helpful to you in getting the right Lug or Terminal for every application.

Sherman can produce practically unlimited quantities of standard or specially designed Lugs and Terminals. Complete facilities are also available for hot tinning, electro-tinning, cad plating, etc. Write today. Let Sherman engineers help you solve your post-war problems NOW.

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Sherman Closed Round End Soldering Lugs. "Uni-Crimp" Solderless (pressure type) Terminals. Soldering Terminals—hundreds of sizes and styles.

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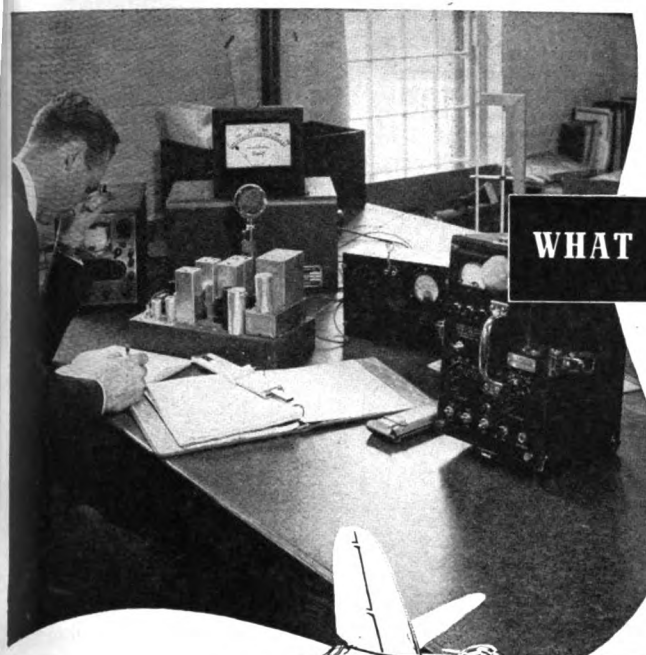
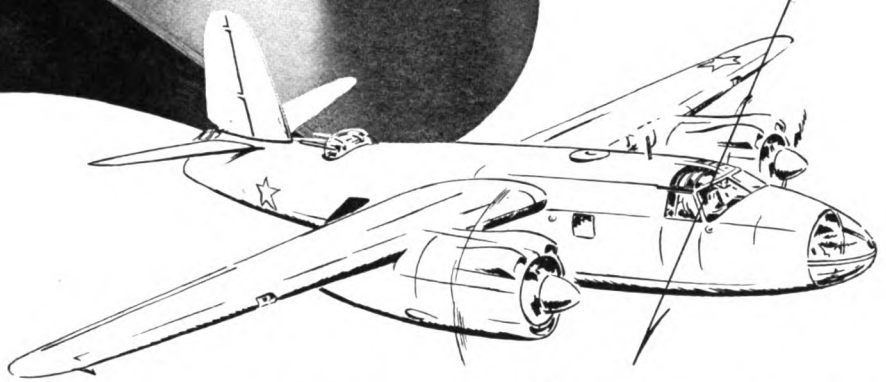


WHAT HAPPENS HERE . . .



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Communications equipment designed for maximum efficiency doesn't roll off a high-speed assembly line. It's got to be painstakingly made that way!

Exacting precision is *engineered into* Harvey-Wells receivers and transmitters every step of the way. From the moment a communications problem is presented to us until the set is shipped out, each separate part, every engineering application, is closely analyzed, rigidly tested, inspected thoroughly and intensively. No gaps—no hurry—no half-way measures. Each piece of equipment must *earn* its own final stamp of approval.

That kind of communications equipment is constructed for *complete dependability*. That's the ONLY kind of communications equipment produced by Harvey-Wells.

Know the company that wants your business! Our CASE BOOK tells the story of Harvey-Wells and its place in Electronics. Send for it today. Your name on your letterhead is sufficient.

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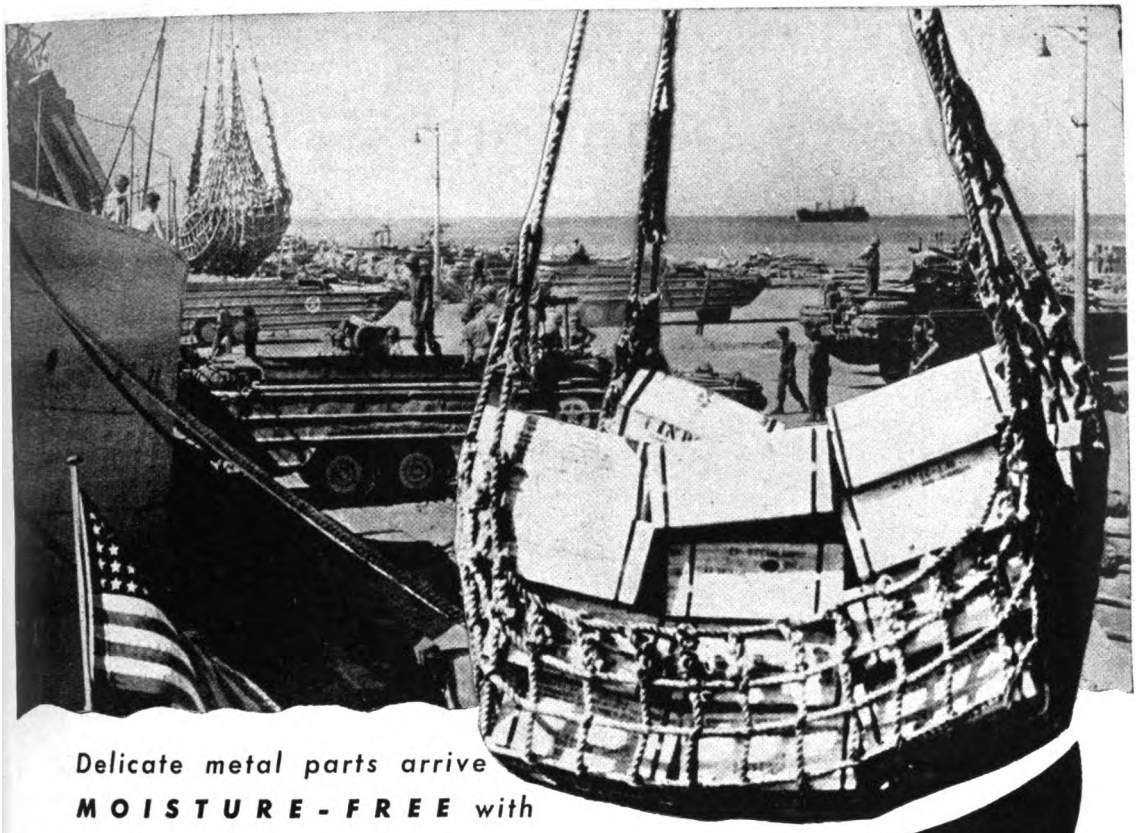

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The power of crystalline Joliet Silica Gel to absorb atmospheric moisture within containers is almost phenomenal. Its drying action prevents rust and corrosion. Moreover, it is widely used as a drying agent in cartons and boxes of foods, fabrics, chemicals and other commodities.

Joliet Silica Gel is strictly a quality product. It is clear white; passes a rigid section test; meets exacting government specifications. Write today for full information.

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There are excellent opportunities for jobbers to build profitable business on Joliet Silica Gel in a few territories. Write for details.

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Crystal Controlled"
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Look at These Features!

- ★ Stable output up to 40 megacycles
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Copies of the catalogue and complete sets of abstracts are on file at district offices of Smaller War Plants Corporation and in many Chambers of Commerce.

For further information write to the Office of Alien Property Custodian, 120 Broadway, New York 5, N. Y., or 135 S. LaSalle Street, Chicago 3, Ill. Indexes and abstracts can also be ordered from either of these offices; make checks or money orders payable to the Alien Property Custodian.

• • •

F-M and Television Broadcasters Announce Allocations Truce

In a joint action taken May 31 to speed a decision on the seven-year-old struggle between frequency-modulation broadcasting and television for space in the high-frequency radio spectrum, FM Broadcasters, Inc., and Television Broadcasters Association, the trade associations for the two industries, petitioned the Federal Communications Commission to adopt promptly an allocation plan satisfactory to both.

The plan upon which the two rival groups have finally joined hands is the first of the three FCC proposals concerning frequencies between 44 and 108 megacycles. It would give FM broadcasting 90 channels between 50 and 68 megacycles, a range in which present television stations now operate, and would give television 13 channels between 68 and 216 megacycles.

Prompt granting of the request by the FCC would permit both industries to prepare now for vast post-war expansion. It would enable them to avert unemployment which might result during the design and production engineering of equipment and sets. With cutbacks on war contracts already taking place in the electronics indus-

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UALITY COILS AT REASO
more every day, the industry is
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ELL—July 1945

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SUPER-QUALITY COILS AT REASONABLE PRICES

More and more every day, the industry is turning to Albion for fast, quality and quantity production of coils, chokes, and transformers. That's because here you benefit from the unbeatable combination of management "know how," skilled workmanship, streamlined facilities, and central location. Your requirements will be given prompt and thoughtful attention.

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For more than 10 years

we have been manufacturing crystals. Not only are we crystal manufacturers, but crystal specialists as well. Consult us on your "crystal problems".

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PETERSEN RADIO CO.

Council Bluffs, Iowa

CRYSTALS EXCLUSIVELY SINCE 1934

Product efficiency-

thru new concepts in fabricating techniques

One of the fundamental reasons for the widespread utilization of BAER fibre parts in essential applications today is the extra measure of accuracy afforded in fabrication. This fact—explained by the wide latitude of BAER specialized facilities for machining, stamping, punching, drilling and sawing—should step-up the efficiency of your post-war plannings. An inquiry does not obligate you in any way.

Baer

PHENOL AND VULCANIZED

FIBRE FABRICATIONS

FOR INDUSTRY

FREE LITERATURE — BAER engineers have compiled a 6-page data bulletin covering the "how" and "why" of both phenol and vulcanized fibre. A note on your letterhead will bring your copy promptly; write today for Bulletin 120.

N. S. BAER COMPANY, 9-11 MONTGOMERY ST., HILLSIDE, N. J.

try and due to increase as complete victory nears, design and engineering must take place without delay if civilian production is to dovetail with war work.

Music Therapy

USE OF MUSIC from f-m receivers has made it possible for several Chicago dentists to do painful drilling without need for an anesthetic, according to Miss Violet Kmety of Zenith Radio Corp.'s station WWZR.

Speaking during National Music Week in Chicago, she pointed out that music from this station was particularly useful for these purposes since it is largely serious classics and has no distracting commercial announcements.

Other local applications include quieting the nerves and easing the minds of 2,700 donors a week at

At the Helderberg Mountain transmitter site of General Electric Co., near Schenectady, engineer George M. Brown talks with other GE engineers cruising in a 4-w f-m emergency mobile unit. The occasion was a two-day demonstration for members of the New York State chapter of APCO (Associated Police Communication Officers) of Radiotype and v-h-f (161.775 Mc) communications. In the foreground is one of the electromatic typewriters used in the system which involves perforating a tape, passing it over an automatic transmitting head which keys the transmitter with a tone signal, transmitting and receiving the keyed signal and electronically selecting the proper keys on the typewriter at the receiving end

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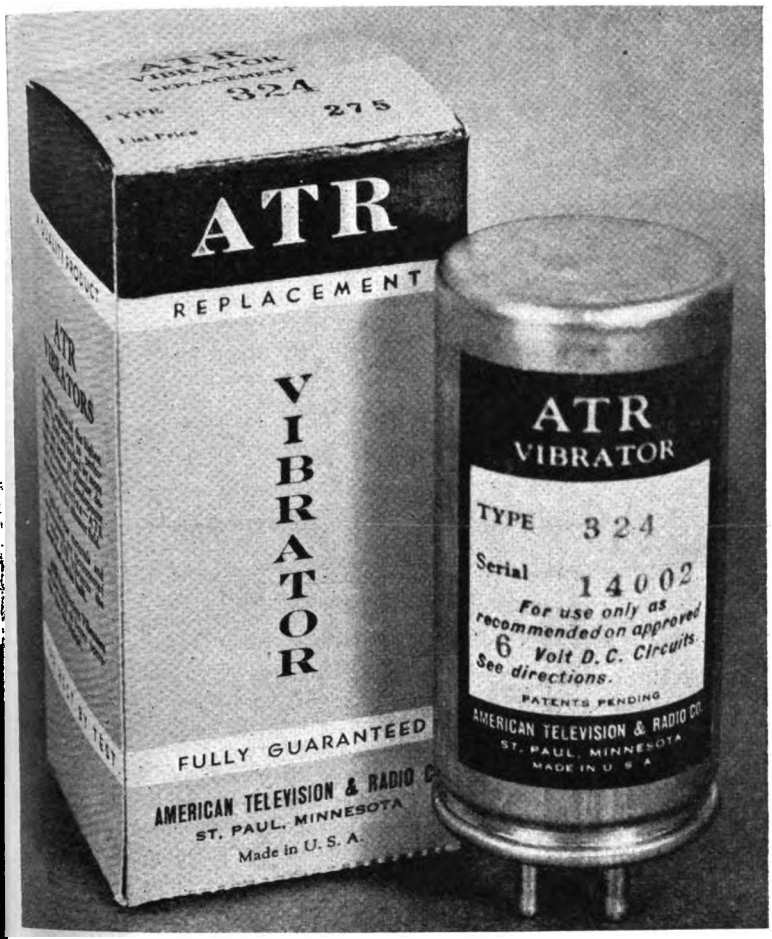

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FEATURE:

- **Longer Life**
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INCLUDE ALL TYPES:

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- **Synchronous**
- **Shunt Coil**
- **Driver Coil**
- **6 to 220 Volt D. C. Input**

INQUIRIES INVITED

ATR Vibrators, the heart of vibrator-operated power supplies, are proven units of the highest quality, engineered to perfection. They are backed by more than twelve years of vibrator design and research, development and manufacturing—ATR pioneered in the vibrator field.

ATR

Preferred Precision Products

- Vibrators
- Vibrator-Operated and
- Rectifier Power Supplies

ATR LOOKING AHEAD! Though now engaged in vital war work, with the immediate aim of victory, ATR is looking ahead. Our organization is being geared for the postwar requirements of the Radio-Electrical Industry. At present, only priority rated orders are being filled. However, we suggest that your postwar orders be anticipated and placed with us for prompt delivery. Write for catalog number 244. Backed by 14 years of "know how," DEPEND ON ATR.

AMERICAN TELEVISION & RADIO CO.

Manufacturers of Quality Products Since 1931

ST. PAUL, MINNESOTA, U. S. A.

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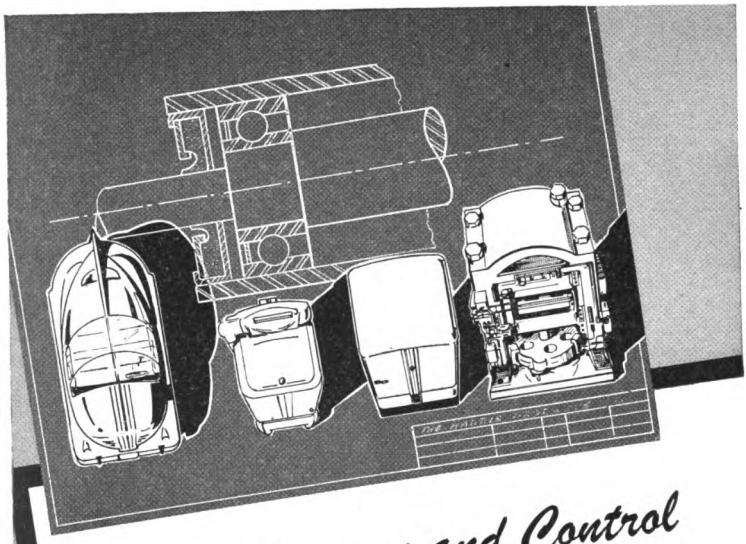

How to Harness and Control
VIBRATION NOISES

Today, vibration control on postwar equipment is a major subject with most of the leading equipment and appliance manufacturers because it adds greatly to the longevity, efficiency and performance of their products. Vibration control also means quiet, smooth operation which in turn is a potent sales point in selling appliances of all kinds.

Harris Torflex Flexible Bearings will prolong life, lower maintenance costs, insure more dependable and accurate operation and increase efficiency. This is done by absorbing shock, controlling vibration, silencing noises, providing flexibility for cushion and misalignment, transmitting torque, and eliminating wear and friction. Harris Torflex Bearings consist of a seamless tube of rubber which has been stretched between two concentric metal tubes, assuring high radial pressure which provides the required adhesion between rubber and metal. Torflex Bearings take axial, torsional, and radial loads and come in a wide range of sizes, carrying loads from ounces to tons. They are widely used and universally approved.

Harris pioneered in the field of engineered vibration control, consequently Torflex Flexible Bearings and Harris Mounts are widely used on prewar equipment, Army and Navy planes, military mobile units of all kinds, industrial equipment, automobiles, electrical and electronic products. If you have a vibration problem, our engineers would welcome an opportunity of working with your engineers, just drop us a line.

HARRIS PRODUCTS CO.
CLEVELAND 4, OHIO
U. S. A.

the Chicago Blood Bank and diverting the minds of caesarian mothers under local anesthetic.

Hundred-Watter Sales

SUPPLEMENTING INFORMATION previously released on standard broadcast stations in other power categories, FCC now announces that net time sales for 1944 among 24 of the nation's 33 standard broadcast stations (28 commercial and 5 non-commercial) operating with power of 100 watts, increased 37 percent over the amount reported for 1943. All stations in this category showed increases. The total was $983,639, an increase of $263,476.

Tropicalization Inspection

AS A RESULT of the increasing pitch of war activities in the Japanese theater of operation, the U. S. Army Signal Corps announces current use of an invisible dye to facilitate inspection of equipment treated for fungus and moisture detection.

This invisible or fluorescent dye is mixed with the lacquer which is sprayed on the equipment. Since the lacquer must be colorless to permit the reading of numbers and identification marks on the surfaces beneath, it is impossible to use visible dyes for determining paint coverage.

Checking is done with a special lamp high in ultraviolet emission and equipped with a deep purple filter.

A quick spot check which is sometimes used for the same purpose is executed with an ordinary pencil. Wherever the pencil glides as if on glass the spraying has been adequately done, but if it starts to write this indicates the presence of a weak spot in the covering.

CONVENTIONS TO COME

SEPT. 17-21. AMERICAN SOCIETY FOR MEASUREMENT AND CONTROL. National Instrumentation Exhibit, Hotel William Penn, Pittsburgh, Pa., L. Susany, secretary, 4400 Forbes St., Pittsburgh, Pa.

WASHINGTON NEWS

EXPERIMENTAL MODELS. In line with its announced policy of permitting reconversion as rapidly as

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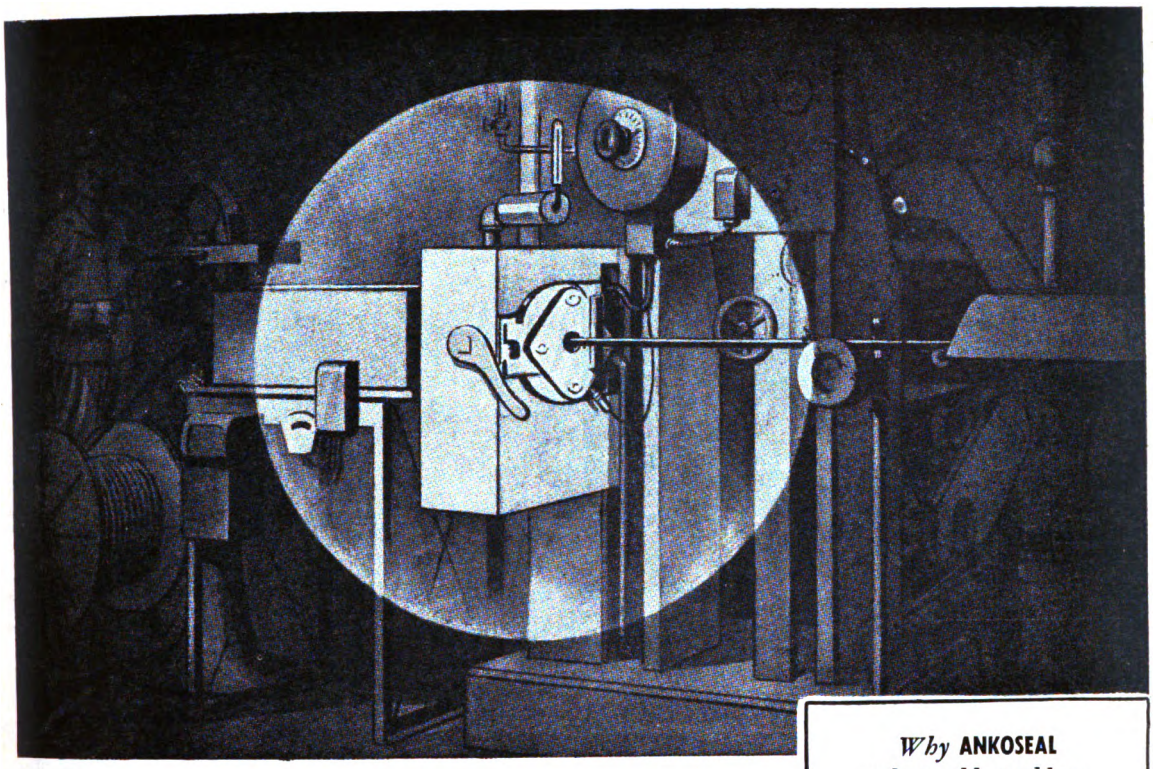

Where's the Engineer in this picture?

THE engineer isn't visible in the sketch—but he's there, behind every step in building Ankoseal cable! For, more and more, cables are engineered *and* manufactured to do particular jobs—especially here at The Ansonia Electrical Company!

Because of the many unusual cable demands of the Army and Navy which we have met, we are able to satisfy equally difficult requirements of other government agencies ...or of private concerns engaged in war work. Once we know what the function of the cable is to be, we take over—and from there to the finished product, in engineering and manufacturing, our organization works to deliver the form and type of Ankoseal cable best suited to that job.

That we stand ready to meet such requirements is indicated by our output record...made possible by "Yankee ingenuity" in manufacturing, implemented by emphasis on *continuing* laboratory research. These same facilities, this same ability, are offered to you.

So—if you have a cable problem—think of Ankoseal—and The Ansonia Electrical Company. We'll be glad to hear from you!

Why ANKOSEAL *solves cable problems*

Ankoseal, a thermoplastic insulation, can help solve many electrical engineering problems, now and in the future. *Polyvinyl* Ankoseal possesses notable flame-retarding and oil resisting characteristics; is highly resistant to acids, alkalies, sunlight, moisture, and most solvents. Polyethylene Ankoseal is outstanding for its low dielectric loss in high-frequency transmission. Both have many uses, particularly in the radio and audio fields. Ankoseal cables are the result of extensive laboratory research at Ansonia—the same laboratories apply engineering technique in the solution of cable problems of all types.

THE ANSONIA ELECTRICAL COMPANY

Specializing in "Ankoseal" a Thermoplastic Insulation

ANSONIA • CONNECTICUT

A Wholly-Owned Subsidiary of

NOMA ELECTRIC CORPORATION

GENERAL OFFICES • NEW YORK, N. Y.

—In peacetime makers of the famous Noma Lights—the greatest name in decorative lighting. Now, manufacturers of fixed mica dielectric capacitors and other radio, radar and electronic equipment.

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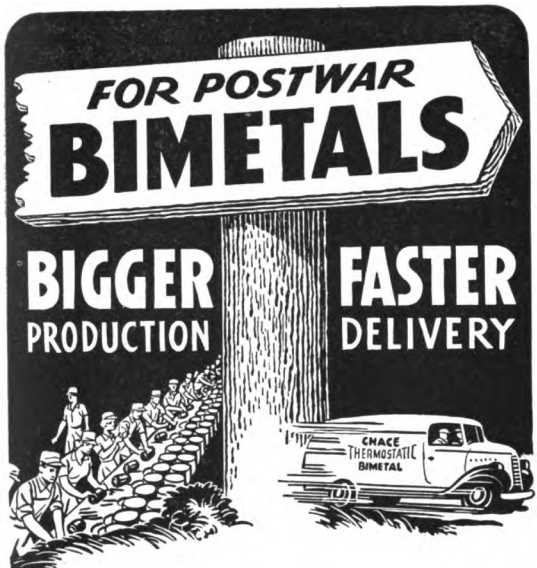

Out of wartime crucibles have come many by-products. Bimetals—developed for war needs—but of profound value in peacetime pursuits.

By new equipment and improved methods, Chace has vastly expanded its facilities for bigger production and faster delivery.

Today, this greater capacity and quickened service is being made available for the postwar demand for Chace Thermostatic Bimetals. To help in the production of such peacetime products as require dependable actuating elements for temperature responsive devices.

W.M. CHACE CO.
Manufacturers of
Thermostatic Bimetals and Special Alloys
1630 BEARD AVE • DETROIT 9, MICH.

CHACE BIMETALS 35 DISTINCT TYPES SOLD IN SHEETS, STRIPS and FINISHED FORMS

possible, WPB has relaxed restrictions on the production of experimental models. Thus, where WPB authorization was required for the expenditure of more than $5,000 in a single plant in any calendar month in making models, no dollar limitation now exists. The order also removes the restriction on exhibition of models to the trade or to the public and permits distribution of experimental models for the purpose of promoting sales and creating consumer demand.

SOUND EQUIPMENT. It is reemphasized by WPB that intercommunication systems and public address systems may not be sold on the basis of maintenance, repair and operating. MRO orders can be used to add stations to existing intercommunication systems or to replace damaged amplifiers where repairs are impossible—but can never be used for installation of sound systems.

RECEIVER PRICE STUDIES. In anticipation of a return to civilian production, OPA (Office of Price Administration) officials are gathering data on manufacturing costs of radio sets, cabinets, and components preparatory to the fixing of ceilings in accordance with existing reconversion policies. From the point of view of parts, the operation comes under the direction of Earle H. Morse, chief of the electrical section, while sets and cabinets fall under the jurisdiction of Daniel L. Jacobs, chief of the radio and miscellaneous unit of the durable goods price branch.

CIVILIAN PRODUCTS RELEASED. Revocation of Order L-325 releases the production of 35-mm motion picture projection equipment, including sound and amplifying systems, for civilian use. Sixty other limitation orders revoked simultaneously cover a wide variety of types of equipment including resistance welders, electric office machines, motor controllers, and automatic music devices.

RECEIVER MARKET. Preliminary tabulations from the fourth nationwide survey taken by the Office of Civilian Requirements of WPB show that consumer demand for household appliances is far in ex-

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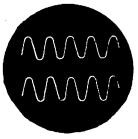
Policing Production

VARIABLE SOUND WAVES

ELECTRICAL WAVES

BROADCAST WAVE

RADIO INTERFERENCE



CHECKING A TELEVISION SET.

with JEROME STILL & MOTION PICTURE CAMERAS

These graphs show what the eye sees on the fluorescent screen of an oscillograph. By using the JEROME Data Camera to photograph these tests at intervals of a few seconds or minutes, as required, you get a permanent record of your tests, and one that may be studied at leisure.

This is only one of many useful tasks on which the JEROME Automatic Still and Motion Picture Camera may be employed.

Changed to a motion-picture camera at the flick of switch, the JEROME makes Time Studies in Electronic Manufacturing. Or – it portrays shop methods, for instructing novice workmen in their training period. See the 28 uses outlined in the table opposite.

This rugged, 35mm camera, with every part strongly built to resist vibration or shock, is extraordinary in so many ways that we may only hint at them here.

For instance, heating equipment, controlled by thermostat, permits motion-pictures at a temperature of 60° F. below zero. For work in the dark, or in shadowy spots the camera provides its own illumination.

There are two shutters, one for each class of work, and mounting for three different lenses, of which two are provided as standard equipment.

Speeds – On Movie Work – approximately 4 to 64 frames per second. On Data Work – intervals of from 15 seconds to 30 minutes. Furnished with substantial tripod, or may be rigidly clamped to bench or fixture. Read all about this unusual Industrial Camera. WRITE FOR FULL INFORMATION.

28 Ways to Use JEROME Cameras

1 Photograph instrument panels, registering instruments, single, multiple frame, at pre-determined intervals.
2 Gun camera – recommended for heavy guns – 35 mm. Superiority over 8 mm., 16 mm.
3 As an Ordinary Camera: Despite special design camera can be used as regular 35 mm. camera.
4 Ground and aerial reconnaissance, surveys.
5 Recording duplications, Maps, Mail, valuable documents.
6 Medical research, fluoroscope screen and microscopic photographic recording.
7 Chemistry, records chemical research & action.
8 Coast Survey, Aerial Reconnaissance. Recording of depth and sounding instruments.
9 Buoy survey and patrol of sea in critical areas.
10 Electronic Research Instrument, photographically records cathode ray, oscilloscope.
11 Detection, automatically photographs objects passing within camera range.
12 Test work, general instrument, recording test performances, techniques.
13 Training Film, all types of school and educational photographs for training purpose, class room.
14 Deck Observation Camera, records deck action or position of ships in convoy.
15 Production Check Camera, checks machine, manual operations, increasing efficiency.
16 Aerial observation. At pre-set intervals will photograph landscape below at high altitudes.
17 Engineering Work. Used in construction of ship hulls, bridges, construction analysis.
18 Performance Guide, manual operation, gun crew action. Recording for future study.
19 Aircraft Landings & take-offs mounted on control tower. Records unusual incidents.
20 Aerodynamics research and flight test operations.
21 Material Testing. Automatic testing characteristics of materials, recording for analysis.
22 Meteorology. Isolated weather instruments and cloud formation and climatic study.
23 Traffic Check. Dangerous road intersections. Tunnel and bridge traffic analysis.
24 Marine observation, underwater photography fuora, fish habitats.
25 Firing Data Recording. Complete gun firing record, corrector range and site.
26 Front Line Warfare. Tank and listening post observation.
27 Restricted Area Detection. Registers pedestrian traffic thru gates, doors.
28 Photoelectric Cell operating camera operating from sound and vibrator detection.

JEROME ENGINEERING CO.
MASSAPEQUA, L. I., N.Y.
ORIGINATORS OF THE AUTOMATIC RECORDING CAMERAS
BUILDERS OF PHOTOGRAPHIC EQUIPMENT
UNIVERSAL CAMERAS FOR EVERY TECHNICAL REQUIREMENT
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QUICK DELIVERY ON LEADING MAKES OF

WIRE & CABLE

for Radio and Power Use

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Meeting urgent needs for Wire and Cable is a *specialized* job at ALLIED. From this *one central source,* shipments go constantly to industry, armed forces, government agencies and research laboratories. Here are gathered *all leading makes, in all wanted types,* for radio and power use.

BELDEN ALPHA LENZ CORNISH
ANACONDA CONSOLIDATED AMPHENOL

Power • Multi-Conductor • Solid and Stranded
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Microphone • Intercom • Hook-up • High-Tension
Magnet • Aerial • Twisted Pair • Lamp Cord

Large and varied stocks of Wire and Cable are maintained for *rush service.* Close contact with manufacturers expedites procurement. Whether your requirements be large or small—save time and work—call ALLIED first!

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SUPPLIERS OF ELECTRONIC PARTS AND EQUIPMENT TO INDUSTRIAL AMERICA
Electronic Tubes, Rectifiers, Power Supplies, Intercommunicating Systems, Sound Systems, Photo-Cell Equipment, Batteries, Chargers, Converters, Generators, Supplies for Resistance Welders, Fuses, Test Instruments, Meters, Broadcast Station Equipment, Relays, Condensers, Capacitors, Resistors, Rheostats, Transformers, Switches, Coaxial Cable, Wire, Soldering Irons, Microphones, Speakers, Technical Books, etc.

cess of the demand in any year before the war. Including only households, and not apartments and new housing, the figures represent demands as of the date of the survey, which was shortly before V-E Day. Assuming that supplies were ample, it is projected from the results that 5,085,000 radios were in demand as against only 2,682,000 a year ago. From the second-hand point of view it was brought out that 429,000 households had sought unsuccessfully to purchase radios, while 913,000 found units to buy. 13 percent of these were new. Radios were the only items among household appliances where the number actually bought exceeded the number looked for unsuccessfully.

QUARTZ CRYSTALS. An amendment to Conservation Order M-146, issued by WPB, eliminates the provision for application of certain quartz crystal production under the spot authorization plan. Consumers in hardship cases are directed to appeal by letter to the Miscellaneous Minerals Division. The new order allows the use of quartz in the manufacture of research or production instruments on any ratings and also eliminates a former prohibition against fabricating radio oscillator plates and filters from quartz scrap.

FCC ACTS

To permit this station:	To do this:
WJXN Jackson, Miss.	Operate a new station on 1490 kc, 250 w, unlimited time.
WJAX Jacksonville, Fla.	Operate new auxiliary transmitter.
WPAG Ann Arbor, Mich.	Operate a new station on 1050 kc, 250 w, daytime.
W4XAP Birmingham, Ala.	Operate a new developmental broadcast station on frequency to be assigned, 250 w.
W2XCS New York, N. Y.	Extend completion date for new experimental television broadcast station to Nov. 12, 1945.
— — — — Cadillac, Mich.	Construct a new station to operate on 1240 kc, 250 w, unlimited time.
KEUB Price, Utah	Change call letters to KOAL.
WSTN Staunton, Va.	Construct a new station to operate on 1400 kc, 250 w, unlimited time.
— — — — Tulare, Calif.	Construct a new station to operate on 1240 kc, 250 w, unlimited time.
— — — — Milwaukee, Wis.	Construct a new developmental broadcast station at the transmitter site of WMFM. Emission: A0 and special for FM.
WLBG Philadelphia, Pa.	Change call letters to WIBG-FM.
KCRA Sacramento, Calif.	Operate a new station on 1340 kc, 250 w, unlimited time.
WBHD Petersburg, Va.	Change call letters to WSSV.

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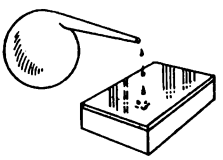
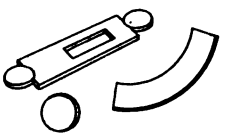
What do you need in metals ?

ECONOMY

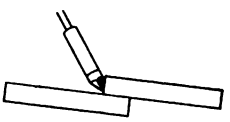
CORROSION RESISTANCE



EASE OF FABRICATION

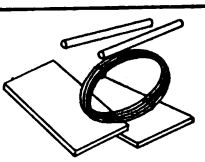


EASY SOLDERING



ELECTRICAL CONDUCTIVITY

SHEET, WIRE, TUBE



You'll find the answer in General Plate Laminated Metals

The versatility of General Plate Laminated Metals makes possible the fabrication of parts with exceptional electrical performance . . . corrosion resistance . . . mechanical and structural properties . . . long wearing life . . . and economy.

By permanently bonding precious metals to base metals, General Plate Laminated Metals give you solid precious metal performance at a cost slightly higher than the base metal. Base to base metal combinations provide special performance requirements not found in single base metals.

No matter what your metal requirements in such applications as electronic devices, electrical products, signal control apparatus, chemical equipment . . . anything from peanut radar tubes to giant turbines, it will pay you to investigate General Plate Laminated Metals for present and post-war products.

They are available in sheet, wire and tube form . . . inlaid or wholly covered . . . or as fabricated parts. Many new clad combinations, developed since the war, are also now available. Our engineers are available for consultation. Write for their services.

General Plate Division

of Metals & Controls Corporation

50 Church St., New York, N. Y.; 205 W. Wacker Drive, Chicago, Ill.; 2635 Page Drive, Altadena, California; Grant Bldg., Pittsburgh, Pa.

ATTLEBORO, MASSACHUSETTS

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Rotary speeds from 600 to 600,000 RPM — or vibrations from 10 to 10,000 CPS — can be "stopped" and studied with the Model 1200 Stroboscope. The light source is mounted in a small probe at the end of a five-foot flexible cable.

This makes it easy to examine small objects at close range. Provision is made to operate the unit from external tuning fork or crystal standards, where extreme accuracy is required. The motion of objects moving at irregular speeds may also be "stopped" with the Model 1200. An accurate repetitive pulse rate is obtained, as the pulses are derived from a stable audio oscillator.

Not only does this eliminate the necessity for constant readjustment of the repetitive rate, but it also insures clearly defined images at high speeds.

For greater flexibility, a light intensity control switch is also provided. This enables the user to control both the intensity of the light and the duration of the pulse length.

WRITE FOR DESCRIPTIVE BULLETIN

COMMUNICATION MEASUREMENTS LABORATORY

Rotobridge • Electronic Generators • Power Supply Units

120 GREENWICH ST., NEW YORK 6, N. Y.

— — — — Massena, N. Y.	Construct a new station to operate on 1340 kc, 250 w, unlimited time, contingent on WPB authorization.
— — — — Santa Maria, Calif.	Construct a new station to operate on 1450 kc, 250 w, unlimited time, contingent on WPB authorization.
KINY Juneau, Alaska	Operate with increase in power, newly installed transmitter, and changes of antenna.
— — — — Columbis, Ohio	Construct a new relay broadcast station to operate with WOSU.
W7XTE Portland, Ore.	Extend completion date of new developmental broadcast station to Dec. 30, 1945.
W3XPA, W3XPC, W3XP Philadelphia, Pa.	Increase power to 40 w, add A3 emission; change antenna and transmitter; and change area to Washington, Philadelphia and New York.
W3XPD, W3XPE, W3XPF, W3XPG W3XPH, W3XPI, W3XPK Portable-mobile	Change power to 40-w (peak) visual, 40-w aural, change type of transmitter and antenna, extend commencement and completion dates of experimental relay station to 60 and 180 days, respectively, change areas to Central Maryland, N. E. Maryland, S. E. Pennsylvania and District of Columbia.
W3XPR New York, N. Y.	Modify construction of new experimental television broadcast station to increase power to 40 w, add A3 emission, change area to Washington, Philadelphia and New York, change transmitter and extend commencement and completion dates to 60 and 180 days, respectively.
— — — — Portable-mobile	Construct new experimental television relay broadcast station to be used with WPTZ.
WGY Schenectady, N. Y.	Operate with decrease in power and changes in transmitting equipment of auxiliary.
WMAZ Macon, Ga.	Operate auxiliary transmitter and move to site of main transmitter with increase in power to 1 kw and use of DA for day and night operation.
WEHS Chicago, Ill.	Extend completion date of new f-m broadcast station to July 8, 1945.
KOB Albuquerque, N. M.	Extend for 6 mo. operation on 770 kc, 25 kw night, 50 kw-ls. unlimited time.
KVSO Ardmore, Okla.	Increase nighttime power from 100 to 250 w.

BUSINESS NEWS

JEFFERSON-TRAVIS RADIO MFG. CORP., makers of communications equipment, and Fonda Corp., manufacturers of continuous sound recording equipment, are merged into the Jefferson-Travis Corp.

RAYTHEON MFG. CO. moves the New York offices of its radio receiving tube division from 420 Lexington Ave. to 60 East 42nd St.—the Lincoln Building, New York, N. Y.

BELMONT RADIO CORP., as agent of Defense Supplies Corp., takes over a plant containing 72,000 sq ft. of floor space to serve as a regional redistribution center for surplus military electronic and radio material.

PHILCO RADIO AND TELEVISION CORP. has formed a new television broadcasting division which brings together all Philco telecasting activities including operation of

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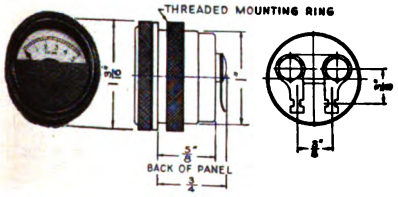
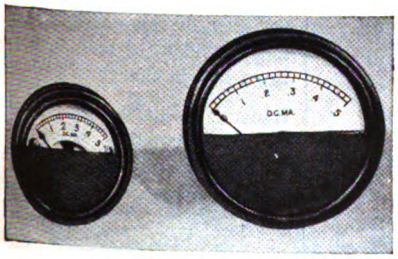
MB MAKES THEM . . .

the smallest millivoltmeters — voltmeters — ammeters milliammeters and microammeters



Mounting Dimensions — model 100



MB Miniature Ammeters
—at left, 1 inch diameter, model 100;
—at right, 1½ inch diameter, model 150.

for Aircraft and Portable Equipment

TINY ENOUGH to fit into the smallest space, this unusual new MB series of electrical indicating instruments, will meet most exacting, rigid tests for accuracy, performance and durability. They are hermetically sealed in a rugged anodized aluminum case which, in turn, can be sealed to the mounting panel itself. Wherever space and weight in electrical indicating instruments are at a premium, this new MB series is the answer.

In addition to the one inch meter, MB also makes a one and one half inch meter, weighing one and one half ounces, with the same type of construction and offering the same advantages.

Write for new catalog to Dep't. E, The MB Manufacturing Company, Inc., Instrument Division, 250 Dodge Avenue, East Haven 12, Connecticut.

THE MB MANUFACTURING COMPANY, INC.

INSTRUMENT DIVISION

250 DODGE AVENUE, EAST HAVEN 12, CONN.

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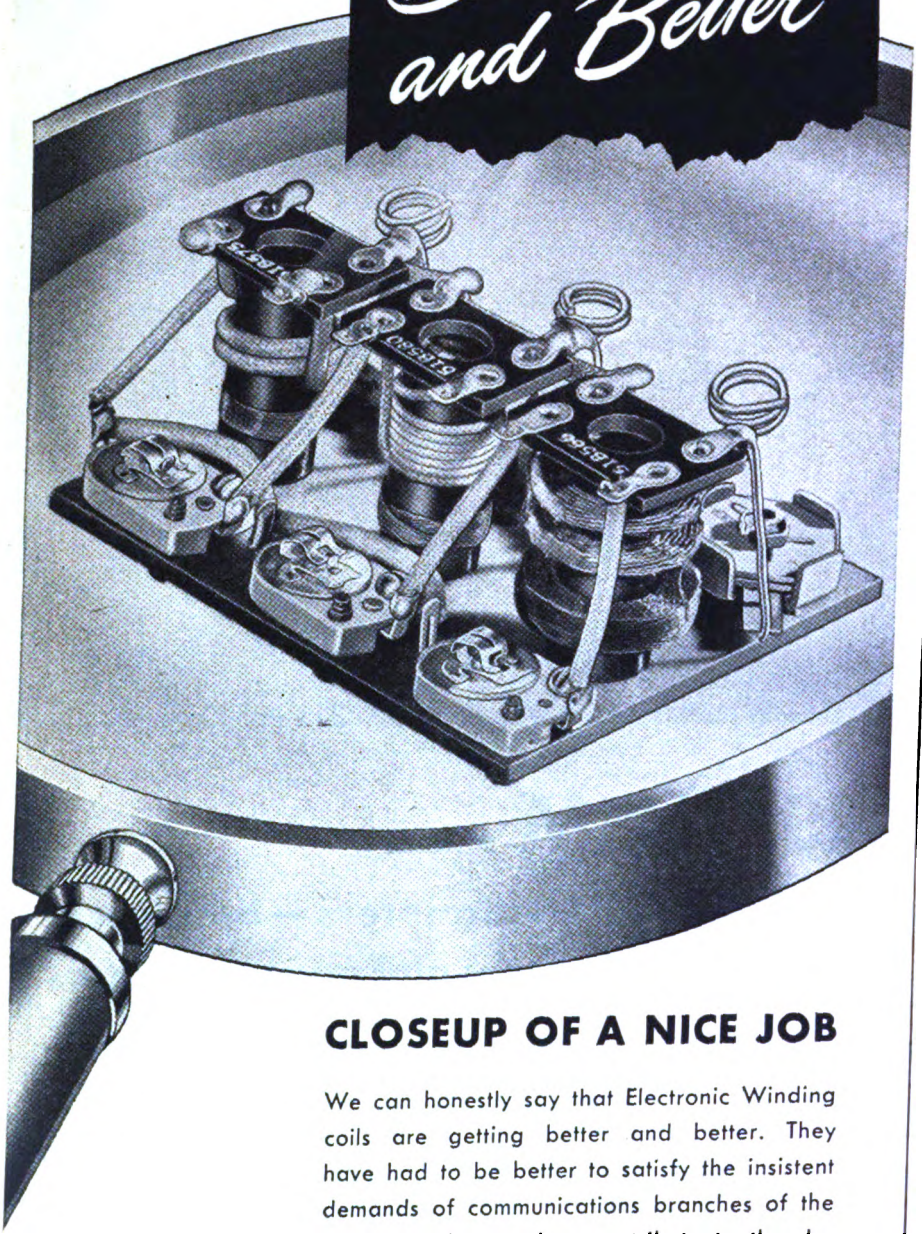
Better and Better



CLOSEUP OF A NICE JOB

We can honestly say that Electronic Winding coils are getting better and better. They have had to be better to satisfy the insistent demands of communications branches of the armed services and to contribute to the dependability of rugged radio equipment that is helping to save lives all around the world. This closeup of a nice job of coil winding shows a complete RF assembly — just one of the many precise jobs we can do. If specifications call for a coil of *extra quality* call on Electronic Winding.

Electronic Winding Co.

5031 BROADWAY
CHICAGO 40, ILL.

★ ★ MANUFACTURERS OF EXTRA QUALITY COILS FOR PRECISION COMMUNICATIONS EQUIPMENT

Station WPTZ and the new sion network between Wash and Philadelphia.

RADIO CORP. OF AMERICA is ing under a unique manpowe ing plan with Prudential Ins Co. at Newark, N. J. RCA stalled a production operati the premises of the insuranc pany and employs a group

company's personnel for part operation. The illustration s a view of the 40 Prudential typists and clerks who are wo in two shifts of four hours on a simple assembly operatio miniature electron tubes.

PERSONNEL

HARRY C. INGLES, major gen Chief Signal Officer of the A was presented with an hono degree of doctor of engineerin the trustees of the Universit Nebraska for his outstan accomplishments in the field communications engineering.

RALPH R. BEAL, assistant to vice president in charge of Laboratories and for nine y research director of RCA, beco vice-president of RCA Commun tions Inc. in charge of engineer

GEORGE T. BROWNELL, signal cer and lieutenant colonel in 11th armored division, is m chief engineer of the Maje

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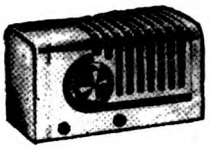
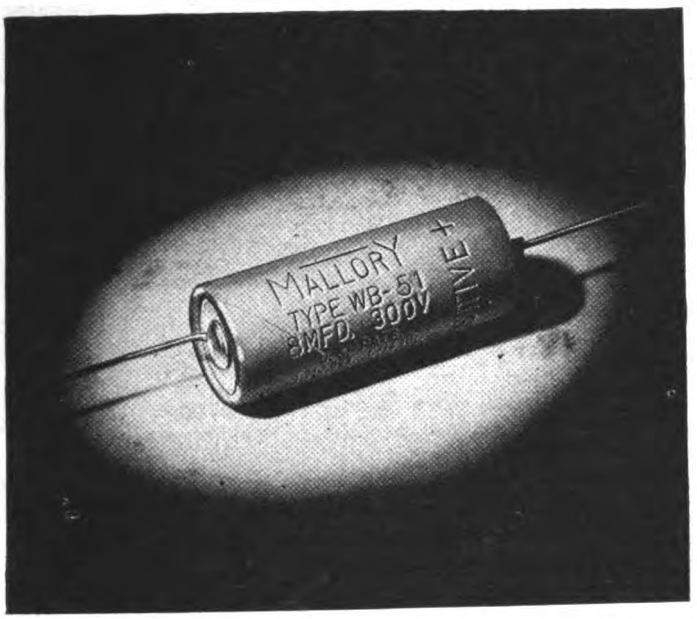


Save Chassis Space with
MALLORY "WB" CAPACITORS



WHEREVER chassis space has to be figured in fractions of an inch . . . in small AC/DC receivers, for instance . . . you'll be wise to specify Mallory "WB" Capacitors. These dry electrolytics are designed and built to combine top efficiency with minimum size for their capacity rating.

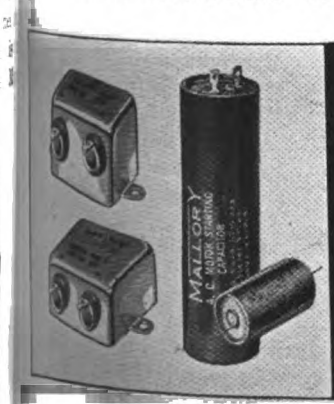
To prevent moisture absorption, loss of electrolytic, and to withstand destructive temperature changes, each "WB" capacitor is hermetically sealed in an aluminum case and is covered with a waxed cardboard tube that avoids shorting in crowded installations.

End-sealing wax has been eliminated to reduce the length still further.

Mallory "WB" Capacitors are available from stock in rated capacities from 10 mfd. at 25 volts to 16 mfd. at 450 volts.

The Mallory catalog, listing characteristics of "WB's" and other Mallory precision capacitors, variable and fixed resistors, switches, vibrators, rectifiers and other electronic parts, is available *free* from your nearest Mallory Distributor. Ask him for a copy, or write us today.

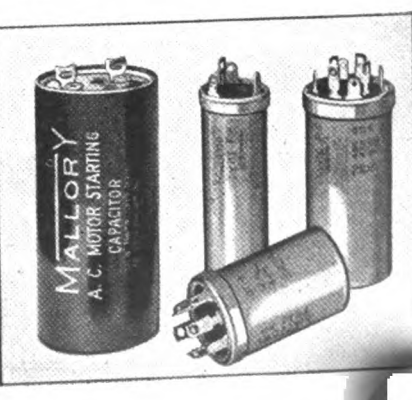
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA



P. R. MALLORY & CO. Inc.

MALLORY

Electrolytic, Film and Paper CAPACITORS



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SOLID AND LAMINATED PRECIOUS METALS FOR NEW INDUSTRIAL USES

Radio and Radar . . . antenna tuners, wave guides and stabilizers . . . function at new high levels of efficiency because of laminated precious metal tubing and solid coin silver tubing.

The entire Electrical Industry has been quick to recognize the fact that laminated precious metal tubing maintains delicate electrical properties without variance under any climatic or atmospheric conditions. It is therefore ideal for electronic applications, high frequency radio parts and delicate instrument assemblies.

Gold, silver, platinum and palladium or special precious metal alloys laminated to base metal have made these things possible . . .

- **The desirable electrical, mechanical or chemical qualities of the precious metals have been added to the strength or other desirable properties of base metals, precisely where and as required.**
- **Precious metal properties of corrosion resistance, electrical superiority, and durability are obtained without solid precious metal costs.**
- **Uniform maintenance of lamination ratios with no porosity, pit marks or defects.**
- **Finer, more lasting finishes than are otherwise obtainable in base metals.**

Almost every conceivable shape of tubing may be had. Rings, sleeves and jackets are quickly and economically cut from laminated tubes. Machining and forming operations can often be eliminated or reduced by the use of specially shaped tubing.

To assist you in the application of our products to your products we are maintaining a staff of thoroughly experienced metallurgists, chemists, designers and consultants . . . an up-to-date research and testing laboratory . . . and a splendidly equipped tool room. These are all at your service to cooperate with your own staff to the full extent of our facilities.

Your inquiries are cordially invited. Ask, too, for a copy of our new descriptive folder.

START RIGHT with Makepeace PRODUCTS

SHEETS • WIRE • TUBING • SOLDERS
FABRICATED PARTS AND ASSEMBLIES

D. E. MAKEPEACE COMPANY

Main Office and Plant, ATTLEBORO, MASS. New York Office, 30 Church St.

Radio & Television C
Charles, Ill.

HARVEY W. SMITH, electr
neer specializing in tra
design, joins the engineer
of Glenn-Roberts Co.,
Calif. He will head the
and development activitie
company.

STANFORD C. HOOPER, f
navy radio and consulting
for Automatic Electric
cago, Ill., receives the Fra
stitute's Elliott Cresson M
1945. Admiral Hooper was
for his pioneering leadersh
field of radio for the Unite
Navy. In the accompanyi

tration he is receiving the
from Charles S. Pelling, pr
of Franklin Institute, cente
presented at the same ceremo
Franklin Medal to Dr. H
Shapley, director of Harvar
lege Observatories and pro
of astronomy, for his work i
science.

AWARDS

Workers of the following
cerns in the electronics field
been awarded Army-Navy bu
for excellence in production:

Induction Heating Co.
New York, N. Y.

International Detrola Cor
Detrola Radio Div.
Detroit, Mich.

Machlett Laboratories,
Power Tube Division
Norwalk, Conn.

Pilot Radio Corp.
Long Island City, N. Y.

Rauland Corp.
Plants No. 1, 2, 3, and 4
Chicago, Ill.

Sylvania Electric Products, I
Wakefield, Mass.

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106-A SERIES *Amplifiers*

WITH MOUNTING ACCESSORIES

The TYPE 106-A AMPLIFIER is a two-stage medium fixed gain preamplifier, designed for use in high quality broadcast-speech-input or sound systems. The low noise level generated within the amplifier and its excellent frequency response make it particularly desirable. It is small in size. Three 106 amplifiers can be mounted in a 10½" rack space. It requires an external power supply such as the Langevin 201-B.

ELECTRICAL CHARACTERISTICS

GAIN—Approximately 39 db with provisions for decreasing to 29 or 19 db maximum.

OPERATES FROM — Source impedance of 30/250/600 Ohms.

OPERATES INTO—Load impedance of 600 Ohms.

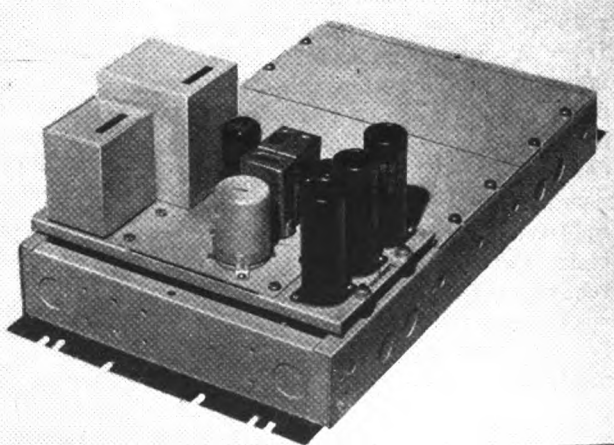
OUTPUT POWER—+16 dbm with less than 1% total R.M.S. harmonic distortion at 400 cycles single frequency.

OUTPUT NOISE—The unweighted noise generated within the 106-A amplifier is equivalent to an input signal of —119 dbm (db below .001 Watts) over a band width of 20,000 cycles.

FREQUENCY CHARACTERISTIC—Production run ±.5 to 1 db over the range 30-15000 c.p.s.

METERING CIRCUITS—Designed for plate current reading on a percentage type meter.

POWER REQUIREMENTS—FILAMENT 6.3 Volts, .6 Amperes. PLATE 275 Volts, 8 Milliamperes.



The type 3A mounting frame, requiring 10½ inches rack space, will accommodate up to THREE 106 Series Amplifiers and is suitable for wall mounting cabinet or rack and panel installations.

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

NEW YORK
37 W. 65 St., 23

SAN FRANCISCO
1050 Howard St., 3

LOS ANGELES
1000 N. Seward St., 38

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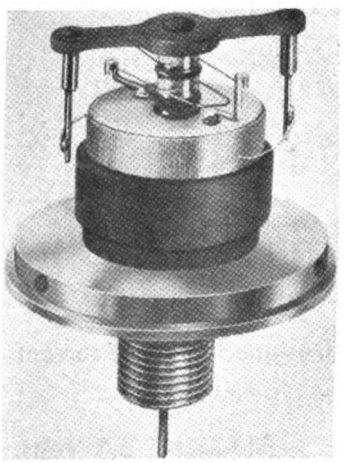
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

High-Sensitivity Resistors

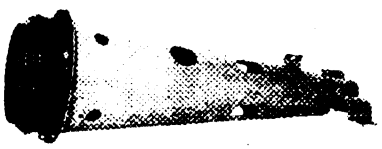
G. M. GIANNINI & Company (161 E. California St., Pasadena, Calif.) state that their autoflight high-sensitivity resistors are the first of their kind to be built in the United States. Overall dimensions of the components are 1¼ x 1⅛ in. diameter and they are capable of producing from a low-torque rotational movement a variable electric resistance. They can be connected directly to sensitive low-torque apparatus such as aircraft flight test



recording instruments and will operate relays or recording systems without the use of amplifiers, and from a simple d-c source. The manufacturer also states that their development is a step forward toward the simplification of delicate circuit measurements, particularly in laboratory or industrial applications where photoelectric cells and amplifiers are required. Units come in various sizes from 100 to 1500 ohms, and from 4 to 15 watts. Only 2 gram-millimeters input torque to overcome friction is required. This low value is secured by use of a jewel-supported shaft, the contact mechanism being made with the accuracy of a fine w[illegible]ch.

Metal Tube-Shield

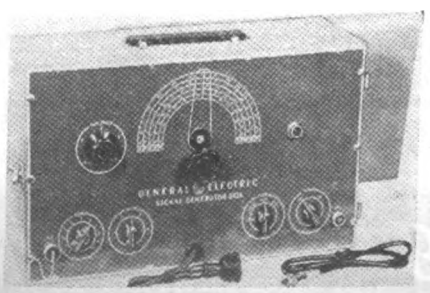
MODEL J-583 shield, for 5-in. cathode-ray tubes, meets Navy requirements for shock resistance. The shield is constructed of 0.025-in. Mu-metal and is hydrogen annealed at 1100 deg C to achieve magnetic



shielding. A rear clamp grips both the tube base and the socket of the tube so as to hold them firmly together at all times. For added shock protection the shields have sponge-rubber linings on the clamp and between the shield hood and the tube face. The shield is easily removed from tubes, when necessary. Metallic Arts Co., 243 Broadway, Cambridge 39, Mass.

Signal Generators

TWO NEW signal generators (Types SG-2A and SG-3A) and a new multi-range measuring instrument (Type UM-4) have been announced by the Specialty Div., General Electric Company's Electronics Department, Schenectady, N. Y. Type SG-2A generator provides a signal source only, the other (SG-3A) gives calibrated output readings. On fundamental frequencies SG-2A covers a range of 100 kc to 32



Mc in five bands which are selected on the front panel. Modulation of the unit (30 percent in accordance with IRE recommendations for receiver testing) is effected by the constant-current method on the plate of the oscillator tube. Changes in line voltage and attenuator settings do not affect the frequency of the instrument. Type SG-3A gives

directly calibrated readings of r-f output, with subdivided readings of signals of 0.5 to 100,000 microvolts at all frequencies from 100 kc to 32 Mc. Signals up to 64 Mc are available by the use of second harmonics. A vacuum tube voltmeter monitors the output of the modulated oscillator to the attenuator while a panel control is used to maintain a constant level. Five complete reading scales are possible.

Type UM-4 Unimeter can be used

in cathode-ray tube and television high voltage uses, as well as in industrial and radio maintenance where voltage, current and resistance measurements are required. Safety protection on the meter is provided for the operator. On d.c. the unit operates from zero to 10,000 volts at 20,000 ohms per volt. On a-c ranges it operates from zero to 10,000 volts at approximately 5000 ohms per volt. Direct-current ranges extend from 100 microamp

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FOR QUICK VISUAL INDICATION

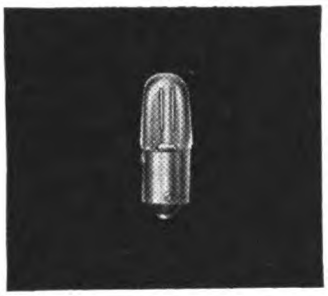
Investigate the Unique Characteristics of G-E Neon Glow Lamps

The unique characteristics of General Electric Neon Glow Lamps recommend them for a variety of uses in radios and electronic devices . . . as indicators, voltage regulators, pilot lights and test lamps.

The uses described at right are typical. If you think G-E Neon Glow Lamps can be useful to you, write or phone the address below. Experienced General Electric Lamp Engineers will be glad to discuss your problems with you.

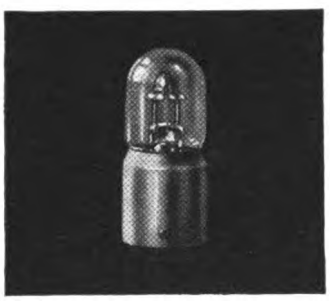
CONSIDER THESE ADVANTAGES

1. Distinctive orange-red glow—no colored cover glass needed.
2. Dependable performance and long life—rated at 3,000 hours.
3. Very low current consumption—less than ½ milliampere for smallest lamp.
4. Variety of sizes and wattages.
5. High resistance to vibration, shock.
6. Normally usable on a-c or d-c.
7. Screw base lamps for 105-125 v. circuits; similar lamps available with bayonet bases, but external resistance required.
8. Produce practically no heat.
9. Nearly flat volt-ampere characteristics.
10. Insensitive to voltage variations above critical value.



NE-51 For general indication, such as showing existence of potential across various parts of electrical circuits.

NE-2 One of the most widely used indicator and test lamps — popular because of compactness and small size. Nominal wattage is only 1/25 watt. This lamp is unbased—has wire terminals.



NE-48 (also NE-16). Indicator lamps. Special volt-ampere characteristics of these lamps indicate use as voltage regulators. Screw base lamp available as NE-45.*

NE-17 Indicator and pilot light lamp that flashes to show condition of B-battery in portable radios. Frequency of flashes decreases as battery runs down.

**NE-16 meets JAN-1A specifications for 991. Special marking JCG-991 supplied for small extra charge.*

ORDER NO.	NE-2	NE-51	NE-17	NE-48	NE-16 ④	NE-45	NE-30	NE-32	NE-34	NE-36	NE-40	NE-42
Watts, Nominal	1/25	1/25	③	¼	¼	¼	1	1	2	2	3	3
Volts (Circuit)	105-125	105-125	③	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Starting Voltage ① AC	65	65	③	65	—	65	60	60	60	60	60	60
Starting Voltage ① DC	90	90		90	⑤	90	85	85	85	85	85	85
Base	★Unbased (Wire Terminals)	★S. C. Bay. Min.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	Cand. Screw	Medium Screw	★D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.
Maximum Overall Length	② 1 1/16"	1 3/16"	1½"	1½"	1½"	1 3/16"	2 1/16"	2"	3 5/16"	3¾"	3 5/16"	3¾"
List Price (plus tax)	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

① Applies to lamp when new.
② Glass part; wire terminals extend additional 13/16".
③ Designed for DC flashing operation in RC circuit.
④ Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
⑤ Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).
★ All Bayonet Base Lamps Need External Resistance.

For further information, write address below for Bulletin 7100

NELA SPECIALTY DIVISION LAMP DEPARTMENT

GENERAL ELECTRIC

1 Newark Street, Hoboken, N. J.

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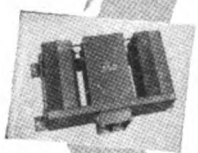

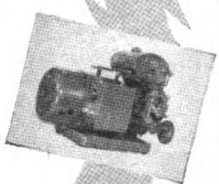

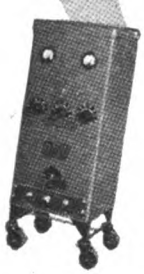

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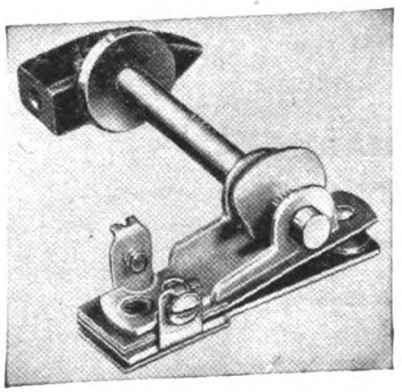
to 10 amp in 6 steps, and resistance measurements are provided from 3000 ohms to 10 megohms in 5 steps.

Thermostatic Switch

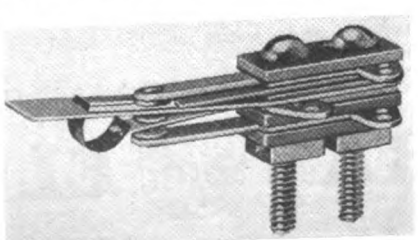
THIS NEW DUAL cam-adjusted thermostatic switch (rated at 1500 watts, 115-230 volts) can be used for either or both a thermostat and a manual switch. It eliminates the necessity of an additional on and off switch and permits instant adjustment of the thermostat. It is designed for mounting on the bottom of electrically-heated equipment such as glue pots, hot plates,



etc., where a manual on and off knob is desired. The knob which controls the temperature setting can be located any distance from the thermostatic element by lengthening the cam shaft. The unit is available in three adjustable temperature brackets: 50 to 300, 50 to 450, and 50 to 700 deg. F. George Ulanet Company, 88 E. Kinney Street, Newark, N. J.

Open Blade Switch

ILLUSTRATED below is a single-pole open-blade switch which is made of berryllium rolling springs. It is rated 15 amp, 115 volts a.c. Overall dimensions are 2 1/32 x 10/16 x 23/64 inches. Contact arrangements are for normally open, normally closed or double throw circuits. Standard operating pressure



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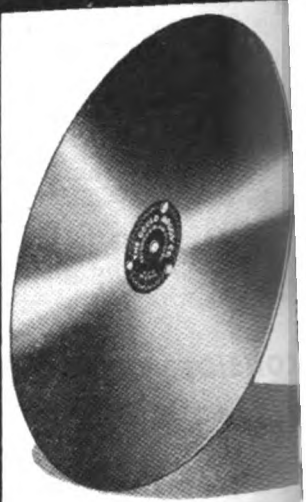

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life will prove the superiority
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of two weights — thin, flexi
interchangeable with aluminu
or medium weight — both w
four holes.

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If you need control or protection, investigate Klixon snap-acting controls. They are available in many standard types to meet most requirements. Write for information, today.

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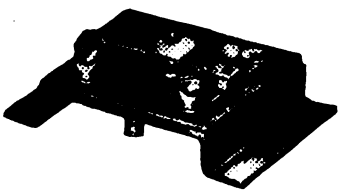
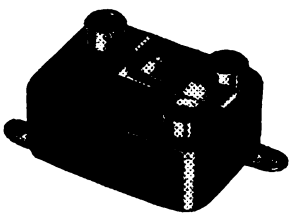
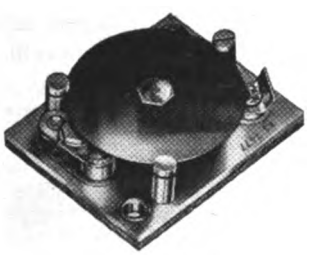
Type RT Thermostat. Adjustable Temperature Control.



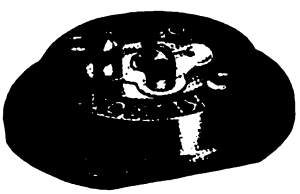
Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.



Type C-7220 Precision Snap Switch 12 amps. 30 Volts D. C., 125 Volts A. C.



Type B-3120 Thermostat and Heater, Crystal Dew Point Control



Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.

Type PM (NAF-1131) Circuit Breaker.

Type ER Series. Ambient Compensated Time Delay Relays.

SPENCER THERMOSTAT CO., ATTLEBORO, MASSACHUSETTS

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SHAFT LOCKS

In addition to the original No. 10060 and No. 10061 "DESIGNED FOR APPLICATION" shaft locks, we can also furnish such variations as the No. 10062 and No. 10063 for easy thumb operation as illustrated above. All types are available in bright nickel finish to meet Signal Corps requirements or black oxide to meet Navy specifications.

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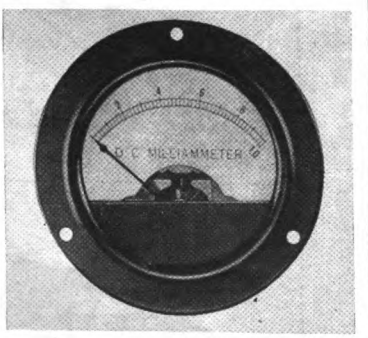
at the end of the blade is from 3 to 6 oz. The manufacturer states that tests of these switches show a mechanical life expectancy of more than ten million operations. Acro Electric Co., 1316 Superior Ave., Cleveland 14, Ohio.

Output Transformers

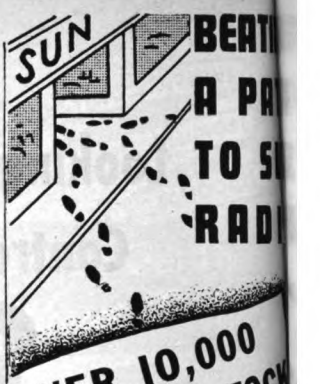
A NEW SERIES of hermetically-sealed aluminum-case output transformers has been designed by The Acme Electric & Mfg. Company of Cuba, N. Y. The manufacturer states the use of annealed steel cores and special vacuum-impregnated coils improves the operating efficiency and over-all performance. Terminals of Pyrex glass with Kovar electrodes and metal collars form a hermetic seal that complies with standards established for 5-cycle immersion tests.

Indicating Instruments

HICKOK ELECTRICAL Instrument Co., 10527 Dupont Ave., Cleveland 8, Ohio, announces new hermetically-sealed electrical indicating instruments with internal pivot construction in 2½, 3½ and 4-inch round styles. Dimensions are in accordance with AWS specifications. The 4-inch types are for radio service equipment where several scale arcs



are required. All three styles include voltmeters, ammeters, milliammeters and microammeters, for both ac and dc. Units can also be sealed with dry air at sea level pressure or inert gas. Glass on the case will withstand 25 lb pressure per sq in. The instruments are vacuum and pressure tested under water. Terminals are special glass soldered-in type using a direct bond of glass to metal.



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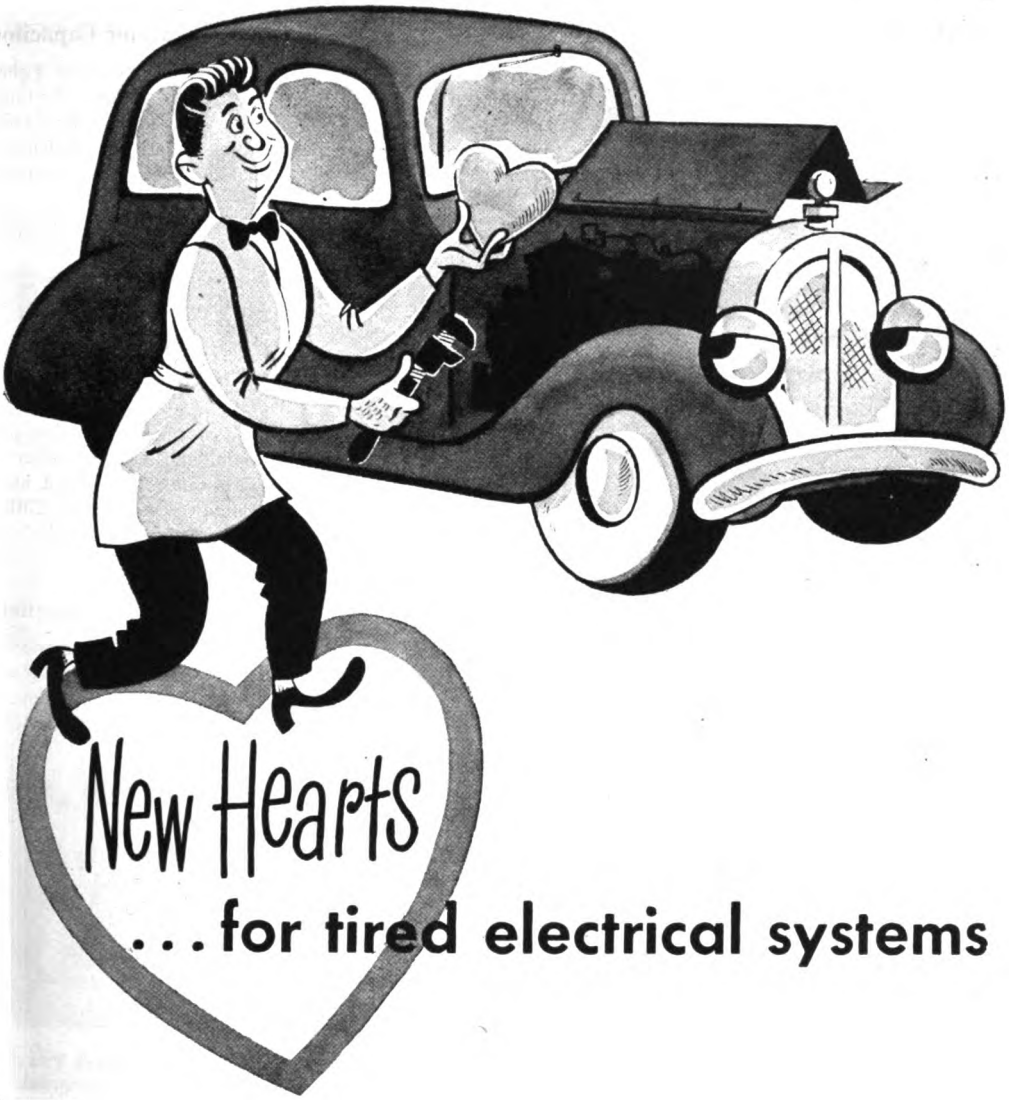

New Hearts ...for tired electrical systems

Keeping America's aging automobiles, trucks, tractors, and buses rolling is a vital wartime task.

Part of this task is performed by General Products Corporation, of Union Springs, N. Y.

They produce what are often called the heart of the electrical system—replacement ignition coils for many makes and models of vehicles.

Thus, when aging electrical systems develop heart trouble, General Products steps in with coils to give them new leases on life—to keep America rolling.

General Products coils are good coils—fully up to their tough jobs. That's why we at Wheeler Insulated Wire Company are proud to supply the coil windings that go into them.

For the 35 years of its existence, Wheeler Insulated Wire Company has devoted its talents and experience to the manufacture of high-quality windings and other wire specialties.

Our entire capacity has been bought by a comparatively few customers—mighty *good* customers!

After the war, we hope to have many additional customers—for our manufacturing facilities have been greatly expanded in the interest of the war effort.

When that time comes—*Remember Wheeler for Windings!*

The Wheeler Insulated Wire Co., Inc.

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Manufacturers of Magnet Wire...Litz Wire...Coil Windings
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● This isn't an unusual statement at all—not when you're talking about punched parts made of Laminated INSUROK! For in the electrical insulation field Richardson *precision* plastics have long been favorite materials . . . used by the millions in all shapes, sizes and thicknesses.

This outstanding preference is easy to understand, for Laminated INSUROK is an easy-to-handle product whose physical characteristics remain commercially uniform. It can be drilled, punched, sawed, turned, planed or milled in your own shop—without special tools—or Richardson Plasticians will do it for you. Write today for the full story about INSUROK . . . laminated and molded.

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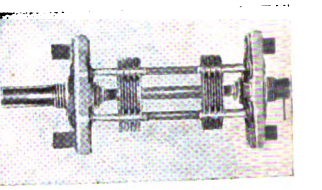
CLEVELAND OFFICE 326-7 PLYMOUTH BLDG. CLEVELAND 15, OHIO

Air-Trimmer Capacitor

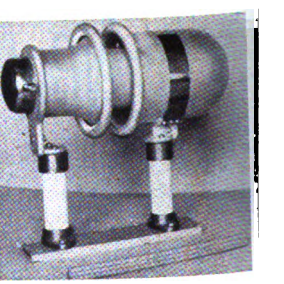
UNITS ARE available either single or dual, in capacitance ranges from 5 to 140 mmf, with standard air gaps of 0.012, 0.015, 0.019, 0.030 or 0.045. Units have ceramic mount-



ing bases, with brass plates an mounting studs of either cadmiun silver or nickel plated, as require Comar Electric Co., 2701 Belmor Ave., Chicago 18, Ill.

Neutralizing Capacitor

TYPE TN capacitor is an additi to the type N line manufactured E. F. Johnson Co., Waseca, Min for use in neutralizing circuits



radio transmitters. Two sizes av able are rated at 45,000 volts 35,000 volts peak breakdown, spectively.

Portable X-Ray Tube

A NEW X-RAY UNIT, using a sh proof tube (approximately 3 in diameter) examines internal st ture of welds, rivets and o points of stress in confined sp (such as airplane wings, fuel ta etc.) The tube is coupled to generator by means of a shockp cable and two small water h The high-loading anode tubes available with targets of co cobalt, iron, or molybdenum. ings range from 10 to 20 mill at potentials up to 50 kv, depen on the target material. N American Philips Co., 100 42nd St., New York 17, N. Y.

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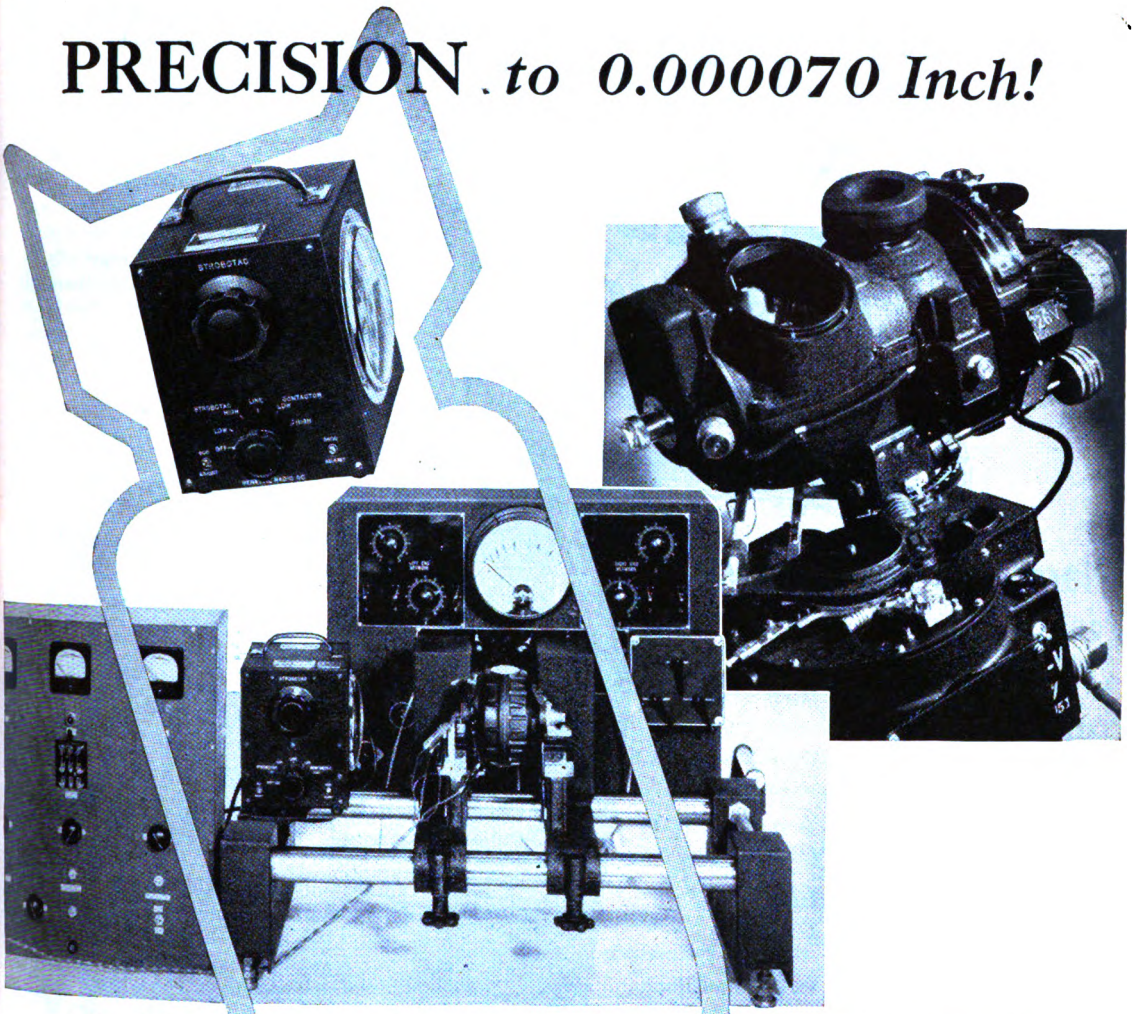
PRECISION . . . to 0.000070 Inch!



● One of the mechanical marvels of the war is the famed Norden Bombsight, until recently one of the most secret of military devices. Information on some of its general features has now been released by the Army.

This bombsight is probably the most precise instrument in the world, yet it is being built in mass production by the Victor Adding Machine Company and several other manufacturers.

The heart of the bombsight and its associated stabilizer are two gyros which have to be balanced to almost unheard-of accuracy. When inspected, the rotor must be centered to *70 millionths of an inch.*

To obtain this accuracy, each gyro is carefully adjusted on the balancing machine shown in the illustration. This portable unit is manufactured by the Gisholt Machine Company. General Radio's STROBOTAC is a part of this machine.

The control equipment at the left includes an electronic speed regulator which maintains the gyro at the speed selected by the STROBOTAC. The equipment behind the gyro measures the amount of weight to be removed from the gyro rotor to give balance, while the STROBOTAC again is used to point out the angular position at which unbalance should be removed.

Gradually as the requirements of military security are relaxed, we hope that we can tell you of many other war uses for General Radio equipment.

In the meantime, possibly your interest in the STROBOTAC is associated with the war effort. **STROBOTACS are available for top-priority war work. If you'd like detailed information about the STROBOTAC, ask for Bulletin 962**

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 1000 N. Seward St., Los Angeles 38

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Now, you can buy a LINGO Vertical Radiator without the use of priorities. Because of the limited amount of materials and components available, orders will have to be filled on a first-come, first-served basis. Until such materials are made available in greater quantities, production will have to be concentrated on radiators not exceeding 250 feet in height. If you are not ready to have the radiator installed at this time, we can arrange to manufacture and deliver the radiator to you with your option to have it installed and erected by us when you are ready. We urge you to act immediately and thus be assured of having your radiator on hand when you want it.

Please include in your inquiries the radiator height required and approximate site so that complete quotations can be immediately made covering the radiator itself and its subsequent erection when so desired.

JOHN E. LINGO & SON, INC.
CAMDEN, NEW JERSEY *Est. 1897*

Submersion-Proof Microphone and Headset

"WATER BUFFALO" is the name of a new submersion-proof lip microphone and headset combination developed by Bell Telephone Laboratories and manufactured by Western Electric Co., 195 Broadway, New York 7, N. Y. The microphone is equipped with an especially designed gland which will pass air but exclude water, and which is capable of withstanding a submersion cycle of 25 minutes under 10 inches of sea water followed by baking in an oven at 125 deg F repeated five consecutive times without damage to the instrument. Not much larger than a half-dollar and less than one-half inch thick, the mike employs the differential principle of operation. When it is properly adjusted before the lips of the user, noise enters from the front and rear in phase and cancels out, thereby making the mike relatively unresponsive to unwanted sounds, yet sensitive to speech. Thus the mike and headset can deliver and receive articulate speech under the most adverse noise conditions. The headset, also submersion-proof, is of a flat-response type. It is fitted with soft neoprene ear-cushions to assure high transmission quality.

Interpolating Counterdial

THESE INTERPOLATING counterdials have the dial coupled directly to the driven apparatus to prevent their getting out of adjustment. The scale graduations run from zero to 100 for each revolution of the dial. Each graduation has two marked divisions, making a total of 200 readable parts on the dial, with the

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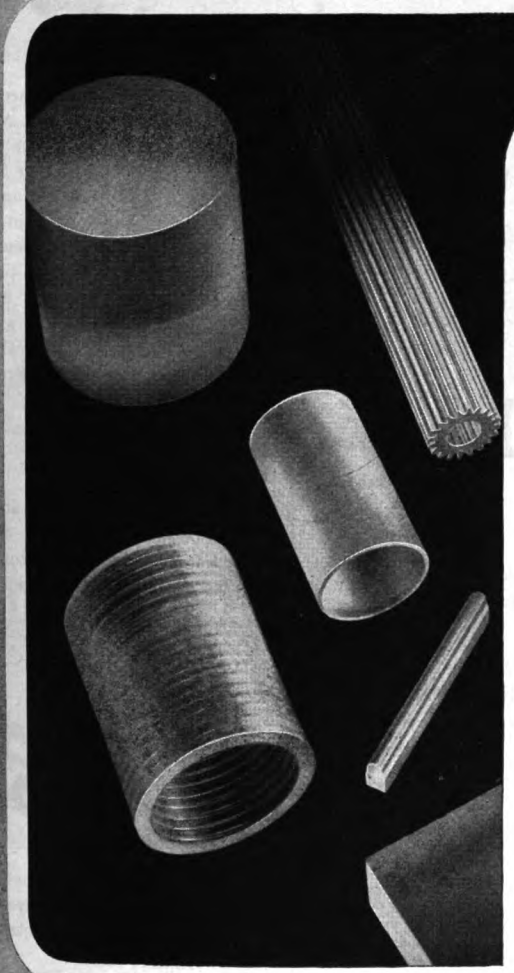
NEW SPECIAL PLASTIC SHAPES BY PLAX



Molding and continuous extruding by Plax, of special shapes in hitherto impossible sizes, open up a whole new realm of plastics applications.

While these applications have been restricted to wartime necessities, and for the most part may not be revealed, the mere indication of the shapes and sizes themselves will excite engineering minds to the visualization of their full possibilities.

The pieces shown in the photograph at the left range from a two-inch-thick slab of polystyrene to a six-inch-diameter cylinder and a four-and-one-half-inch diameter tubing with three-eighths-inch walls. These, the fluted tubing, the piece with varying cross-section, and many other special shapes can be produced in all colors, from crystal clear through jet black, in polystyrene and other thermoplastic materials.

Subsequent machining, with which Plax is thoroughly familiar, can produce unusual structural combinations with superior insulating and other desirable characteristics common to polystyrene and other plastics.

LITERATURE IS AVAILABLE AS FOLLOWS:

Several bulletins on Plax polystyrene products and how to machine them.

A technical article on Plax blown products.

Bulletins on Plax cellulose acetate, cellulose acetate butyrate, methacrylate, and polyethylene products.

Styramic and ethyl cellulose are among the other materials offered by Plax in various forms. In cooperation with the Shaw Insulator Company, Irvington 11, N. J., Plax can give you help covering nearly all plastic materials and methods. For such help, or for any of the literature listed above . . . write Plax.

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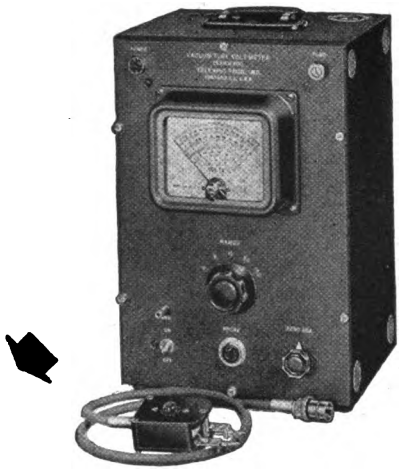
WAR RESTRICTED DEVELOPMENTS



Now Available

in TELEVISO Series 200A Vacuum Tube Voltmeter

TELEVISO, pioneering in the production of measuring apparatus for the **SONIC to UHF SPECTRUM,** has specialized in building dependable Vacuum Tube Voltmeters.

A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable.

FEATURES:

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural.); sub-chassis is ⅛" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.

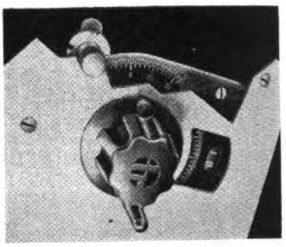
ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shortening of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the field. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts ac. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago.

Televiso Products Inc.

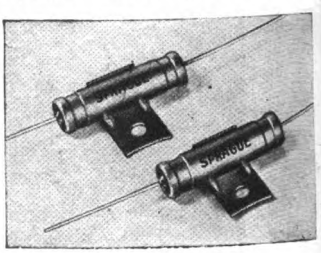
7466 IRVING PARK ROAD **CHICAGO 34, ILLINOIS**



possibility of estimating accurately at least 200 more settings. An additional counting mechanism records each dial revolution, either forward or backward, thereby giving an accurate log of the setting in revolutions and fractions of a revolution. Standard stock units have two digit numbers (from zero to 99) but three digit numbers are available on special order. Technical Radio Co., 275 Ninth St., San Francisco, Calif.

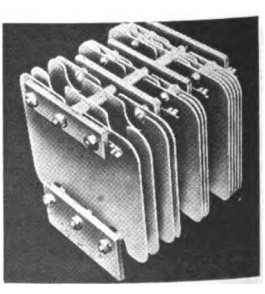
Capacitors

THREE MANUFACTURERS announce new capacitors. The first of these is a non-resonant capacitor called "Hypass" which does not show



resonance at frequencies as high as 50 Mc, and in instances even up to 300 Mc. Sprague Electric Co., North Adams, Mass.

Technical Radio Co., 275 Ninth St., San Francisco, Calif. has added to their line capacitors with from 1 to 4 sections (20, 40, 120 and 230



$\mu\mu$f). Over-all dimensions of this capacitor are 5⅜ x 5¼ in. It is designed for the output sections of a pi-network.

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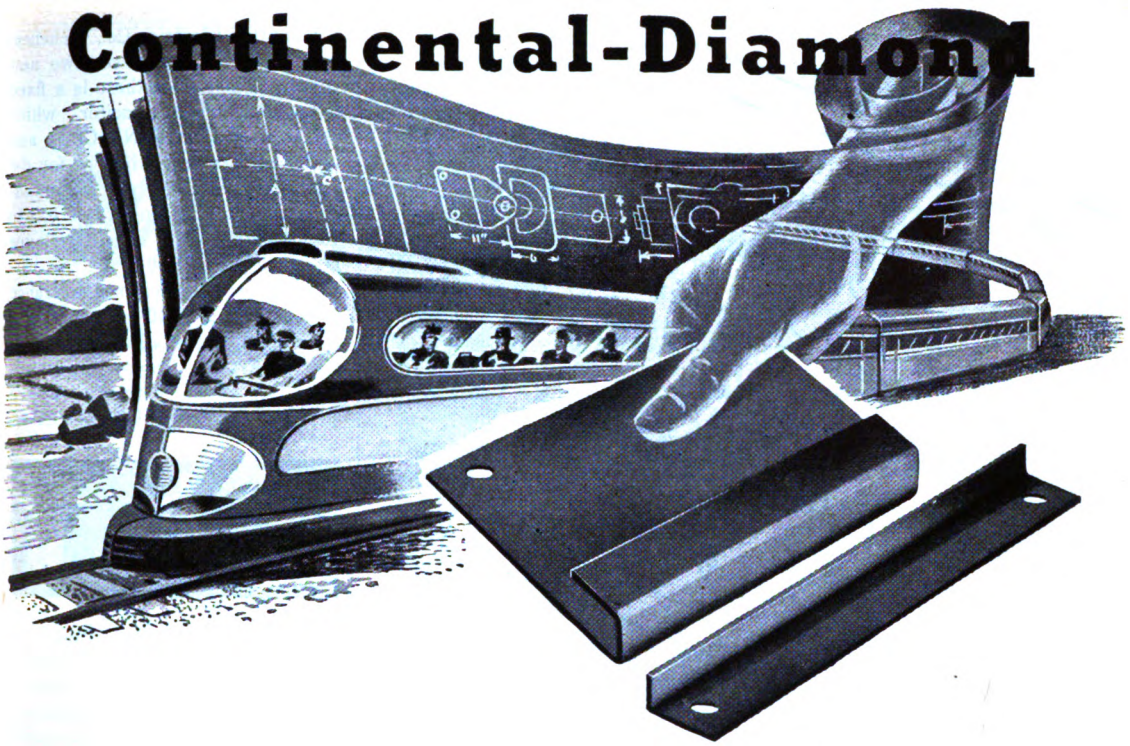
Continental-Diamond



fabricated NON-metallic parts that fit

Pictured are two C-D DIAMOND Vulcanized FIBRE parts that were made from sheet stock... blanked out, smooth shaved, drilled and formed... to customers' blueprint.

ON modern assembly lines, parts must fit! Economical production depends on rapid assembly of units. C-D fabrication methods are engineered to maintain dimensional accuracy just as all C-D products are engineered to meet specific electrical, mechanical and thermal problems.

Manufacturers who demand high standards in needed properties to insure unfailing product performance . . . and who also must have accurately fabricated parts to meet assembly line production problems . . . will want to investigate C-D NON-metallics.

KS-45

C-D PRODUCTS

The Plastics

DILECTO—A Laminated Phenolic.
CELORON—A Molded Phenolic.
DILECTENE—A Pure Resin Plastic Especially Suited to U-H-F Insulation.
HAVEG—Plastic Chemical Equipment, Pipe, Valves and Fittings.

The NON-Metallics

DIAMOND Vulcanized FIBRE
VULCOID—Resin Impregnated Vulcanized Fibre.
MICABOND—Built-Up Mica Electrical Insulation.

Standard and Special Forms

Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

Descriptive Literature

Bulletin GF gives Comprehensive Data on all C-D Products. Individual Catalogs are also Available.

DISTRICT OFFICES

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IN CANADA:
DIAMOND STATE FIBRE CO. OF CANADA, LTD., TORONTO 8

Continental-Diamond FIBRE COMPANY

Established 1895.. Manufacturers of Laminated Plastics since 1911—NEWARK 16 • DELAWARE

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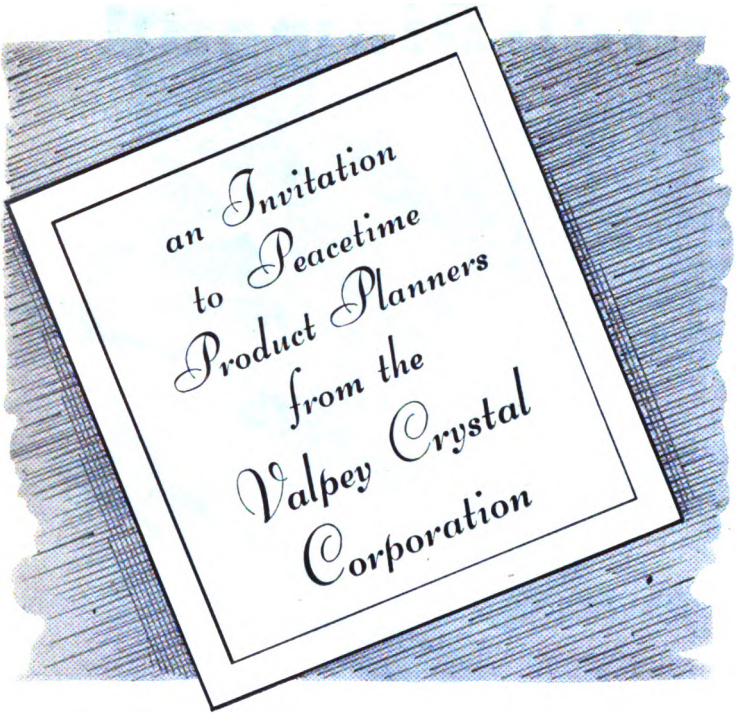
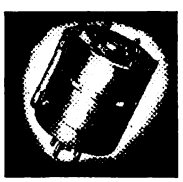


Let Valpey engineers help you plan the "heartbeat" of your postwar product



CBC-0

Where utmost in stability requires constant temperature control.

CM-1

A design for normal frequency control applications.

VP-3

Developed for use in limited space . . . in mobile equipment.

Experienced in volume production of vital crystals for wartime communications needs, Valpey engineers and craftsmen are well equipped to solve any commercial crystal problem. *Insure* the success of your future products by planning to use Valpey Crystals in every "Vital Spot." Valpey's never vary.

Write today for complete "Crystionics" data

VALPEY
Crystal Corp.
CRAFTSMANSHIP IN CRYSTALS SINCE 1931
HOLLISTON, MASSACHUSETTS

General Electric Co., Schenectady 5, N. Y. announces two new types. The first of these is a fixed paper-dielectric capacitor which comes in case style No. CP-70 and is for electronic equipment for d-c applications. There are 268 standard ratings, ranging from 0.1 to 15 microfarad, for circuit voltages from 600 to 12,500 volts. All ratings have a capacitance tolerance of plus or minus 10 percent. Complete data is contained in Bulletin No. GEA-4357. The second capacitor types available from G. E. are case styles CP-60, CP-62 and CP-64

fixed paper-dielectric capacitors with glass terminal seals. The glass seals provide resistance to humidity, fungus growths, and termites. All three case styles are available in both single-section and two-section construction. Capacitance values range from 0.05 to 0.50 microfarad, for voltages of 600, 1000 or 1500 volts.

Current and Voltage Unit

MODEL No. 601 voltammeter consists of an ammeter and a voltmeter which comes in a single case measuring 12½ x 9½ x 10 inches. The ammeter measures from 0.2 to 500 amp in 8 current ranges. The voltmeter measures from 30 to 600 volts in 3 ranges. An inserted primary current transformer with

8-ft secondary leads facilitates measurement of current on 0-100, 0-250 and 0.500 amp scales without subjecting the meter to stray magnetic fields. Scales of the units can be easily and quickly read. Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.

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★ ★ ★ ★ ★

What!... Voluntarily lower the price on a contract already awarded?

Don't be silly!

To lower the price on a contract involving a *new* part is one thing. But when you "bid in" at a lower price than anyone else on a contract covering a device that's already history—and still reduce the figure after the deal is closed—it's something altogether different.

Specifically . . . a contract to turn out a special aluminum part for a major company making automatic pilots for Uncle Sam's fighter planes.

We Cut Our Original Bid to Less Than Half.. And On Top of It Broke a Bottleneck

We bid low, at $38.10 per unit. Up until then, each part required 54 inches of intricate welding—and there had been a shortage of welders capable of doing it. Rejects at testing had been 40%. It had been possible to make only 500 a week.

To boost the output, we looked for a better way of doing it. The answer turned out to be "impact extrusion". Heretofore, manufacturers had used it only for small parts, limited to 2 inch diameter and 3 inch draw. In the process, we eliminated all but approximately 9 inches of welding—plus the need for critical aluminum tubing. Rejections dropped to about 2%. Production jumped to 500 a day, instead of 500 a week.

Our contract price $38.10—but we billed $18.85.

So, Uncle Sam gets the automatic pilots he needs . . . the prime contractor cuts his costs (on top of our original low bid)—and we're feeling very good about it.

Perhaps the fact that we have been in the subcontracting business for over 50 years has something to do with our ability to improve part designs, cut production corners and lower costs.

★ ★ ★

Write on your business stationery for 48-page book, "Let Lewyt Do It"—the story of the Lewyt organization in pictures. Lewyt Corporation, 60 Broadway, Brooklyn, N. Y.

Lewyt

A CONTRACT MANUFACTURER—EXPERTLY STAFFED TO PRODUCE COMPLETE ELECTRONIC AND MECHANICAL ASSEMBLIES, COMPONENT PARTS AND SUB-ASSEMBLIES, TO THE MOST EXACTING REQUIREMENTS

CONTINUE BUYING WAR BONDS

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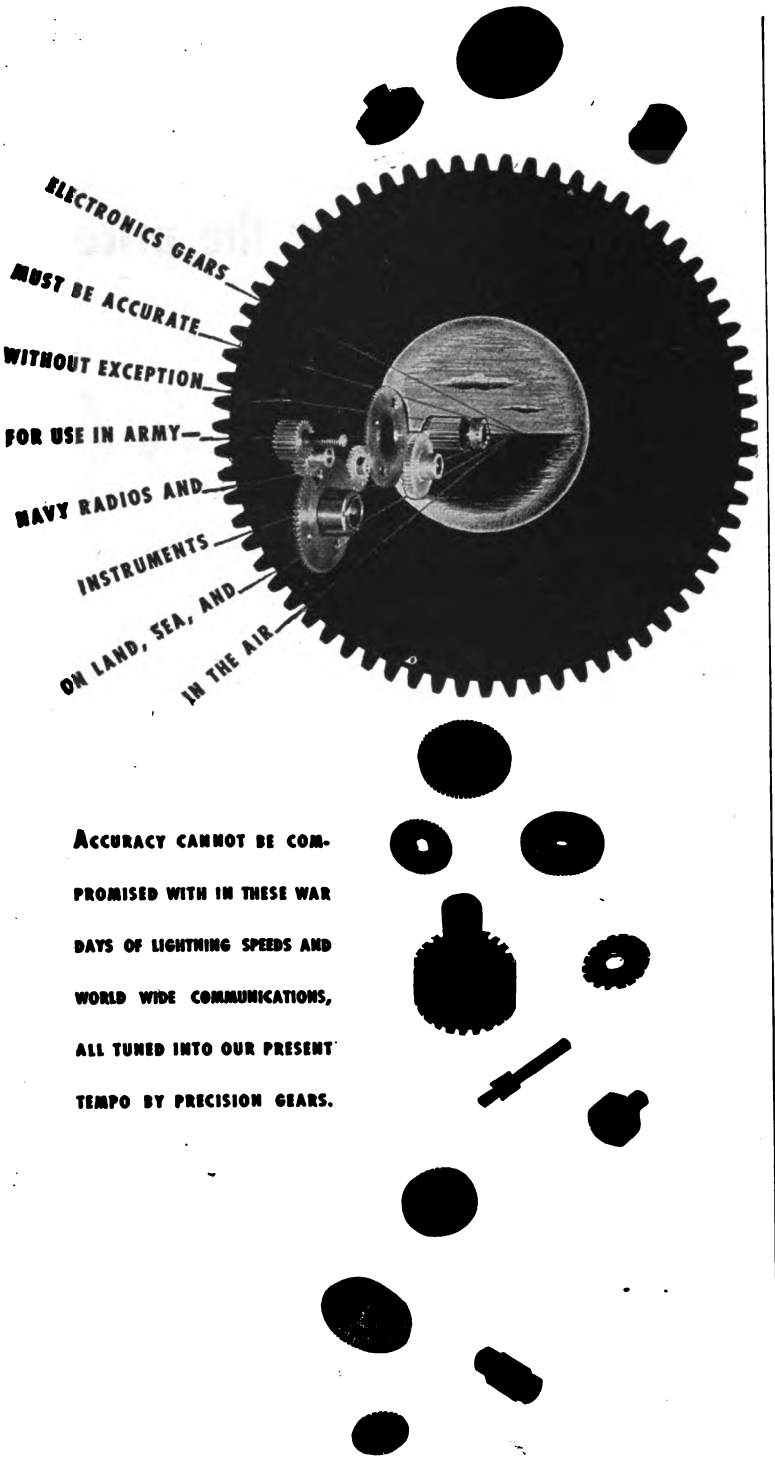
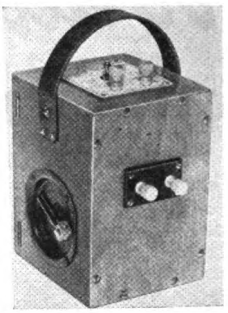


ACCURACY CANNOT BE COMPROMISED WITH IN THESE WAR DAYS OF LIGHTNING SPEEDS AND WORLD WIDE COMMUNICATIONS, ALL TUNED INTO OUR PRESENT TEMPO BY PRECISION GEARS.

Quaker City Gear Works
INCORPORATED
1910-32 North Front Street, Philadelphia, Pennsylvania

Circuit Tester

THIS NEW multi-purpose circuit tester audibly tests continuity and insulation between wires, or from wires to ground. With a special indicator attachment it also determines visually the polarity of wires.



Operation is accomplished by a regulated hand-cranked generator which develops 500-volts d.c. Great American Industries, Inc., Connecticut Telephone & Electric Div., Meriden, Conn.

Multimeter

THIS MULTIMETER, designated as Model PB-200 Speed-O-Meter, has a sensitivity of 2000 ohms per volt on both a.c. and d.c. It measures a-c or d-c voltages up to 1500 volts;

d-c current to 1.5 amp; capacitance to 30 mfd; decibels to plus 58; and resistance to 2 megohms. Superior Instruments Co., Dept. W, 227 Fulton St., New York 7, N. Y.

Snap-Action Switch

A SMALL, push-button, snap-action switch called Snapit operates on a 0.0625-in. movement of the push button and carries a current rating of 10 amps at 115-volts a-c., and 2 amp at 115-volts d.c. The fixed contacts are of silver overlay on phosphor bronze. The contact gap is 0.040 in. on each contact. The

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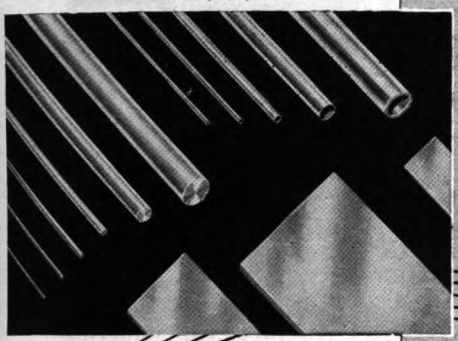
Kovar, the alloy that seals to glass, available as wire, rod, tubing, strip* or foil



Solve Your Sealing Problems...

with KOVAR*-Glass Hermetic Seals

ILLUSTRATED are some of the various forms in which Kovar—the alloy that seals to glass—are available from STUPAKOFF. Kovar—a cobalt, nickel, iron alloy, was developed specifically for sealing to hard glass and has been used commercially for that purpose since 1936.

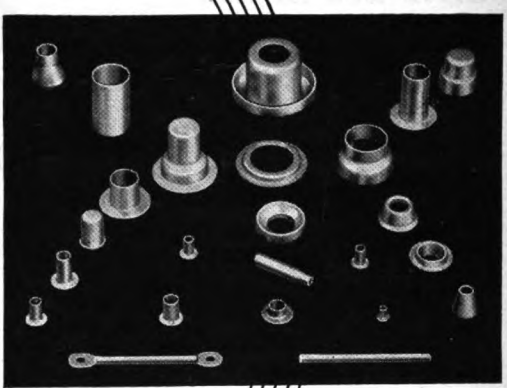
Kovar forms a seal to hard glass through a heating process, in which the oxide of Kovar is dissolved into the glass. The result is a pressure and vacuum tight seal, effective under all atmospheric conditions.

To manufacturers equipped for glass working, STUPAKOFF supplies Kovar as wire, rod, tubing, strip or fabricated into cups, eyelets, leads or special shapes.

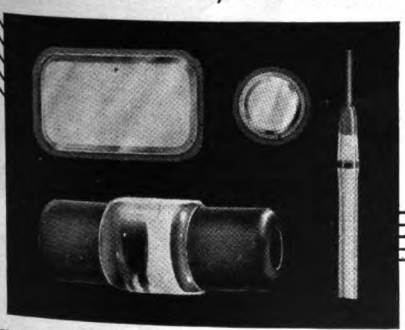
Completed seals are available as terminals with single or multiple, solid or hollow electrodes which can be quickly and easily soldered to a metal container. STUPAKOFF also manufactures meter windows, gauge glasses, graded seals and seals for special applications.

STUPAKOFF engineers will be glad to assist in developing Kovar-glass hermetic seals for your product. The booklet, "Kovar—The Ideal Alloy for Sealing to Glass," will be sent on request.

★ ★ Buy More Bonds ★ ★



Kovar fabricated into cups, eyelets and special shapes



Kovar-Glass meter windows, gauge glasses, and special seals

Complete Kovar-Glass terminals with single or multiple, solid or hollow electrodes

*TRADE MARK 337962 REGISTERED IN U. S. PATENT

ARMY NAVY "FOR BREAT ACHIEVEMENT"

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Products for the World of Electronics

RMA MEMBER

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The "Chin-Up" Girls are in the fight to the finish with . . .

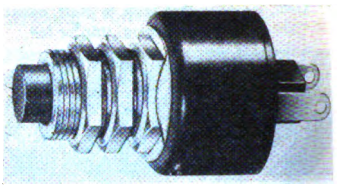
KESTER CORED SOLDERS

● Salute! To our American Women of Industry—for their amazing skill, their stout-hearted stick-to it-iveness! They are in the fight to the finish—and Kester Cored Solders are smoothing the way in hundreds of war plants throughout the nation.
● These uniform, high quality, flux-cored solders are fast, easy to apply, and always permanent—a "must" for speedier production. And like the "Chin-up" girls, Kester Cored Solders are right on the job 'til Victory.

KESTER SOLDER COMPANY

4204 WRIGHTWOOD AVE., CHICAGO 39, ILLINOIS
Eastern Plant: Newark, N. J. ● Canadian Plant: Brantford, Ont.

KESTER
Cored Solders
STANDARD FOR INDUSTRY



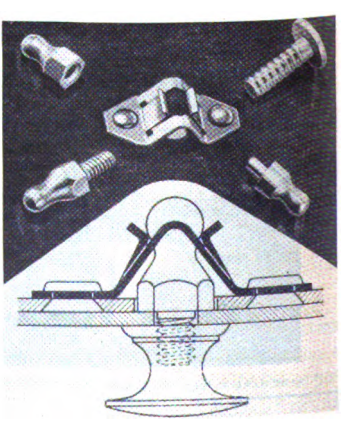
switch has a phenolic body which is round and which measures $\frac{3}{8}$-in. diameter x $1\frac{3}{8}$-in. high. Grayhill, 1 N. Pulaski Road, Chicago 24, Ill.

Adapters for Solderless Wiring

KNIFE-DISCONNECT component parts are manufactured by Aircraft-Marine Products (1591B North Fourth St., Harrisburg, Pa.) for rapid, inexpensive conversion of any existing electrical assembly for use with their knife-disconnect splicing terminals. The adapter is installed in the assembly in the same way as the solder tab it replaces. Adapters for vertical or horizontal conversion for wire sizes from 22 to 10 are available.

Steel Nut Latch

NEW, SPRING-STEEL speed-nut latch, No. 1663, is for instant attachment and removal of box covers, access doors, panels and inspection plates. Three styles of ball studs are available—drilled and tapped for 6-32 screws, threaded shank (632 thread) and plain shank for riveting. These, as well as grooved stud, are provided in various lengths to



suit application requirements. Samples are available but it is necessary to specify pull-out tension required ($3\frac{1}{2}$, 8, 12, 18, or 30 lbs.); thickness

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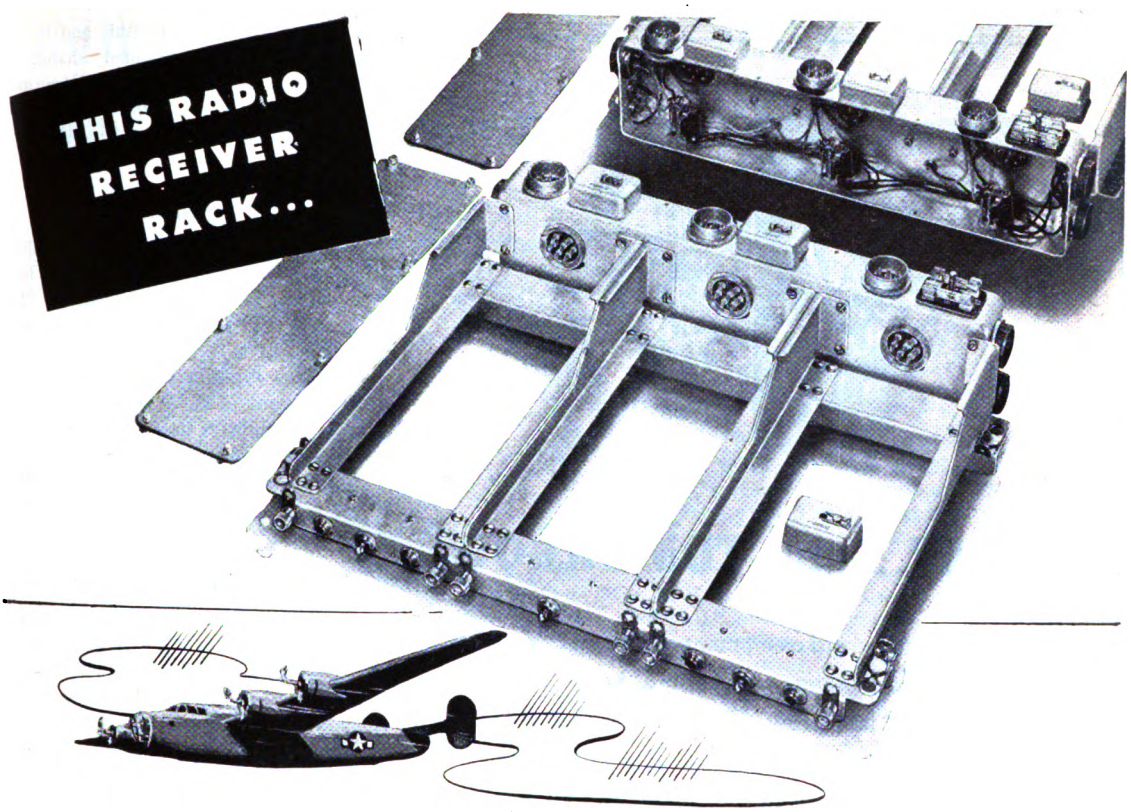

contains more than 500 Electrōnents*

. . . all made and assembled by Scovill

This three-position, high-frequency radio receiver rack for big bombers ...one of the most intricate manufacturing and assembling problems ever entrusted to Scovill . . . shows how Scovill's versatile production facilities can meet requirements for electronic components or complete assemblies.

More than 500 individual parts are assembled in this rack. Materials used range from plastics to metal alloys in the form of sheet, rod, wire and tubing. Scovill makes all except glass and plastics components. Methods include forging, stamping, drawing, heading, machining, and wire forming.

Even complicated wiring does not stump Scovill's production engineers. Every wire is cut to length, stripped and soldered into correct position. Relays are manufactured, tested and adjusted by Scovill technicians.

In other words, Scovill engineered the whole job for assembly-line production...a service that can help you, too, save time, trouble and money on the production of small electronic components as well as large assemblies. For further details about the scope of Scovill's ingenuity and facilities, send for literature. Fill in coupon below and mail today.

*Electrōnents = Electronic Components

Scovill
MANUFACTURING COMPANY
WATERBURY 91, CONN.

Please send me a free copy of *"Masters of Metal"* booklet describing your facilities. I am interested in the ELECTRŌNENT* applications checked.

- ☐ Batteries
- ☐ Record Changers
- ☐ Clips
- ☐ Condensers
- ☐ Dials
- ☐ Escutcheons
- ☐ Jacks
- ☐ Lugs
- ☐ Panels
- ☐ Sockets
- ☐ Stampings (misc.)
- ☐ Tubes

Other applications.....

SCOVILL MANUFACTURING COMPANY

Electronic Division
22 Mill Street, Waterbury 91, Connecticut

Name .....

Company .....

Address .....

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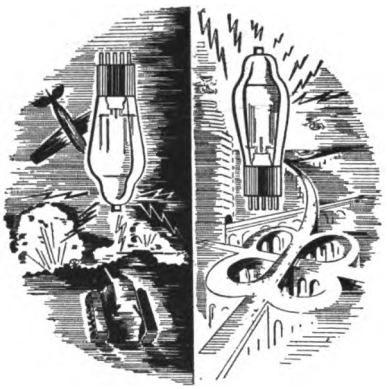

TODAY...and TOMORROW!

Today, the world over, many of the machines and devices of war are shaping the peaceful pursuits of tomorrow. Out of the holocaust of battle will emerge new horizons of human comfort, convenience and safety. The science of electronics marches on!

Today, and every day, Temple engineers and technicians are toiling on new problems, developing new products, improving old ones—dedicated to the task of insuring final Victory—and inspired, as well, to anticipate the peacetime demands of tomorrow.

Temple

Electronics Division

TEMPLETONE RADIO MFG. CORP.

New London, Conn.

of panel to which speed nut will be attached; type of stud; and length of plain or threaded shank, or length of grooved stud. Tinnerman Products, Inc., 2106 Fulton Road, Cleveland 13, Ohio.

Insulating Grommets

FOUR NEW standard sizes of phenolic insulating grommets have been added to the line of Creative Plastics Corporation, 963 Kent Ave., Brooklyn 5, N. Y. These units are screw-type bushings which will not pop out of the chassis when wires are tightly packed through. For speedy assembly the collars are geared and matte finished. Hole sizes vary from $\frac{1}{8}$ to $\frac{1}{2}$-in. clearance.

Electronic Heater

A NEWCOMER TO the electronic-heating field is Climax Engineering Company of Clinton, Iowa, which is ready to go into production of Climax high-frequency heaters which are designed for quick, efficient, localized heat for surface hardening, annealing and brazing. The

equipment can also be used for such food applications as sterilization, pasteurization, deactivation of enzymes, cooking and heating, baking, destroying infestation, packaging and sealing. Climax expects to produce 12 different models of standard electronic heaters.

Vacuum Indicator

FOR TUBE MANUFACTURERS there is a new type vacuum indicator (designated Tru-Vac) which operates from any 110-120-volt a-c outlet. It is scaled to read pressures of a vacuum system from 0.25 to 250 microns, and is accurate to ±2 per-

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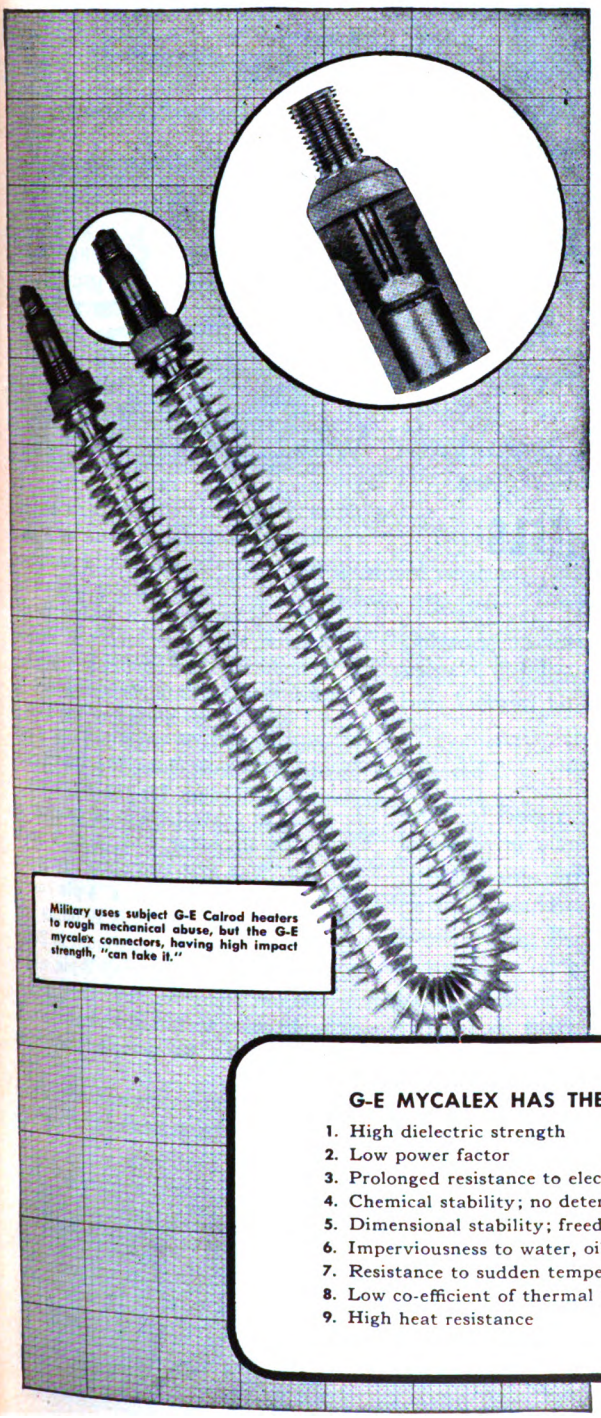
How G-E Mycalex keeps the Calrod dry

AN IDEAL SEAL—IT'S MOISTURE PROOF—IT'S PERMANENT



Military uses subject G-E Calrod heaters to rough mechanical abuse, but the G-E mycalex connectors, having high impact strength, "can take it."

G-E MYCALEX utilizing metal inserts makes this sealed terminal connector for G-E Calrod heaters permanently moisture and oil proof.

AND THE REASONS . . .

(1) Metal inserts can be combined with G-E mycalex during the molding process, and as a result, the metal and the G-E mycalex are fused into an unusually strong bond, locking out moisture, oil and gas.

(2) A permanent seal is assured because of G-E mycalex's unique properties. In this G-E Calrod application it is subjected to temperatures up to 375°C, constant exposure to water, oil and chemical fumes; yet G-E mycalex maintains its dimensional stability and the seal remains unbroken.

Only G-E mycalex was able to solve this tough insulation problem because it has a combination of features not found in any other insulation.

The General Electric Company solved this one and stands ready to put G-E mycalex to work in solving those "impossible" insulation problems of yours.

For further information, write section S-52, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news every weekday 6:45 P.M. EWT, CBS. "G-E House Party" every weekday 4:00 P.M. EWT, CBS.

Buy War Bonds

GENERAL ELECTRIC

PD-68

G-E MYCALEX HAS THE FOLLOWING PROPERTIES:

1. High dielectric strength
2. Low power factor
3. Prolonged resistance to electric arcs
4. Chemical stability; no deterioration with age
5. Dimensional stability; freedom from warpage, shrinkage, etc.
6. Imperviousness to water, oil and gas
7. Resistance to sudden temperature change
8. Low co-efficient of thermal expansion
9. High heat resistance

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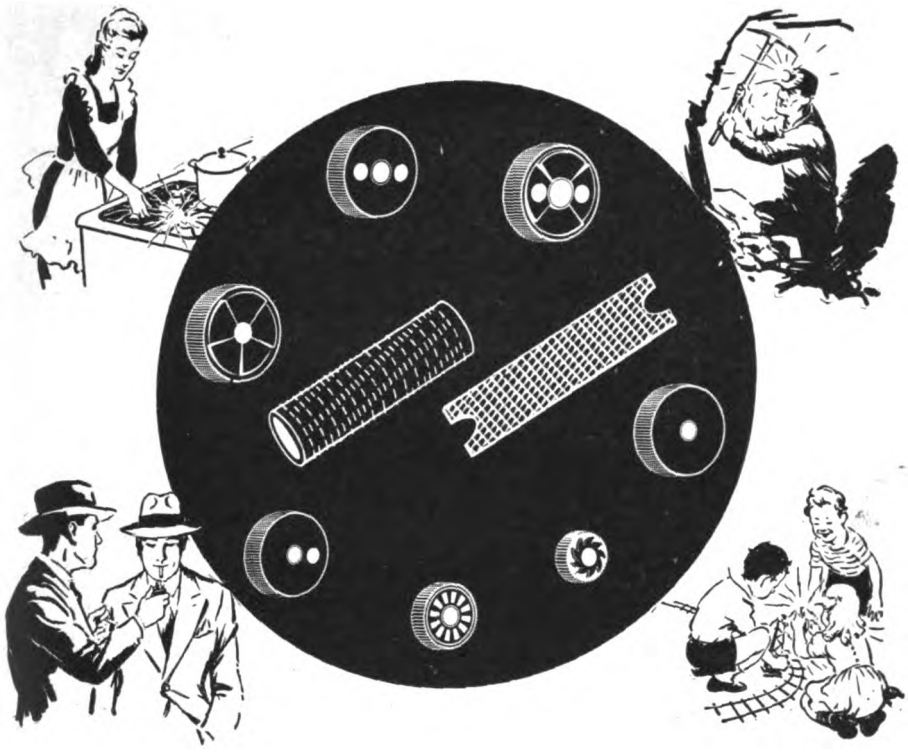


There is no satisfactory substitute for

BUCHMANN SPARK WHEELS

. . . IN THE WORLD'S FINEST SPARKING DEVICES

For 33 years the universal standard of quality for all sparking devices, BUCHMANN SPARK WHEELS are available in stock sizes or made to your exact specifications for all manual and automatic sparking devices.

. . . IN YOUR POST-WAR PRODUCTS

Buchmann manufacturing facilities, greatly expanded to meet the needs of wartime, are today engaged wholly in essential production. But if you plan to manufacture cigarette lighters, gas lighters, mining lamps, sparking toys or other sparking devices, Buchmann Spark Wheel Corporation will gladly share the practical knowledge gained by 33 years of experience in this specialized field. As the world's largest manufacturer of spark wheels, Buchmann Spark Wheel Corporation gives your products the advantage of *recognized top quality in any price bracket*—a factor of first importance in the competitive years ahead.

PRECISION SCREW MACHINE PRODUCTS

Buchmann also manufactures special screw machine products and can assist you in the design and production of parts requiring machining to close tolerances. Inquiries are invited.

There is no satisfactory substitute for precision

PARK WHEEL CORPORATION, 4-20 47th Avenue, Long Island City 1, N. Y.

cent throughout the scale, with stant voltage. Meter may be from a distance, if desired. G unaffected by changes in bar ric pressure. Continental El Co., Geneva, Ill.

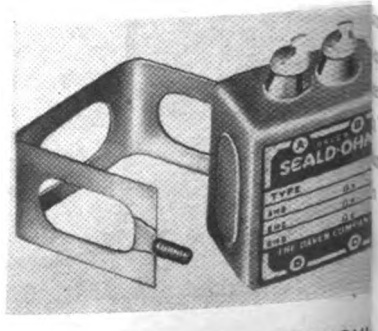
Resistors

NEW TYPE RESISTORS have bee nounced by three manufact

The first of these are Ri precision resistors, Series 82 83, announced by Ohmite Mfg

4835 Flournoy St., Chicago 44 Both types are pie wound to 1 cent accuracy and can be sup with a fungus-resistant coa Type 82 measures ⅛ inches i ameter, and 1⅛, or 1⅜, or 1⅝ in long for the 2, 4 and 6-pie unit spectively. Minimum resistanc 0.1 ohm for all units and the m mum is 400,000 ohms for the 2 unit, 750,000 ohms for the 4 and 1 megohm for the 6-pie u Type 83 is available in three siz ½ inch diameter x 7/16, ⅝ or 1 long. The first two units are 2 while the third is a 4-pie u Minimum resistance is 10 ohms all units, and the maximum is 2 000 ohms for the small 2-pie u 400,000 ohms for the large 2- and 800,000 for the 4-pie u Bulletin No. 125 describes units detail.

Wire-wound "Sealed-Ohm" h metically-sealed precision resist



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IN order to carry out a highly developed program of growth and expansion, we seek to augment the staff of our creative engineering laboratories with outstanding talent...and are prepared to do the things necessary to obtain it.

Applications are therefore invited from key engineers, research men and physicists experienced in industrial electronics, industrial control equipment, the design of automatic machines and allied fields. There are openings to satisfy the chief engineer, department head, project engineer, research engineer and the basic research scientist.

Salaries will at least equal those paid by other leading companies in the field, *but in addition, each candidate will receive a graduated percentage royalty on the sale of all products he develops. A portion of this royalty continues even if he later leaves the company.*

The conditions under which you will work are ideal. Our laboratory—housed in a splendid building—is well-equipped. You will be furnished with everything necessary to carry out the projects under your direction. The laboratory is located in one of the most charming residential communities of southern New England within commuting distance of New York—fine homes, excellent schools, modern shops and stores.

In order to receive fullest possible consideration, your application should present a detailed and comprehensive account of your experience and accomplishments, with particular emphasis on patents you may have obtained and contributions you have made to the origin or improvement of devices or techniques in your field.

The engagement of any candidate, of course, must be in accordance with War Manpower Commission and wage and salary regulations. If your present status precludes a change in position at this particular time, contractual arrangements can be made for you to join the staff at a later date.

We choose not to reveal the name of this corporation in this advertisement but every candidate interviewed will have the fullest opportunity of learning everything he wants to know about us. Further, your letter of application will be seen only by principals and will be held in the strictest confidence. All our staff knows of this advertisement.

Please address your letter to P-860, Electronics, 330 West 42nd St., New York 18, N. Y.

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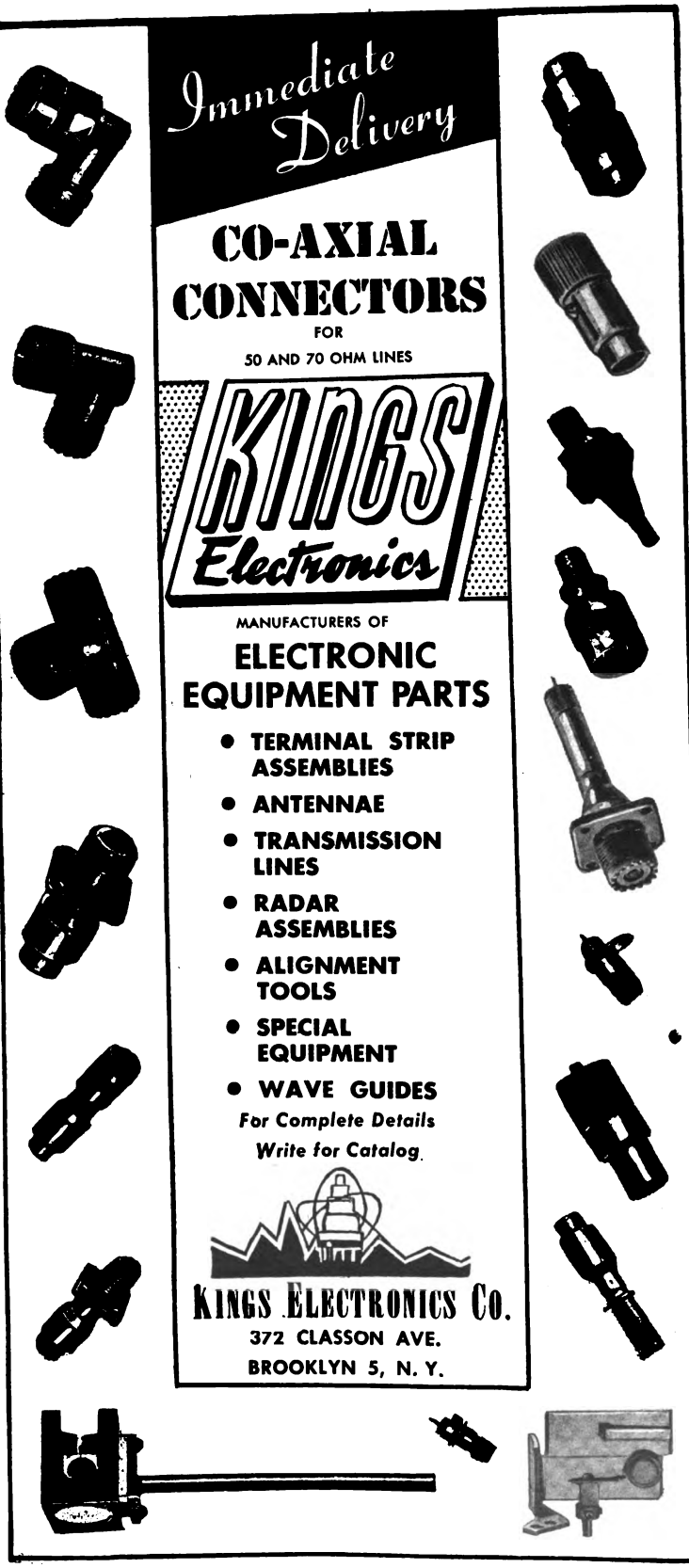
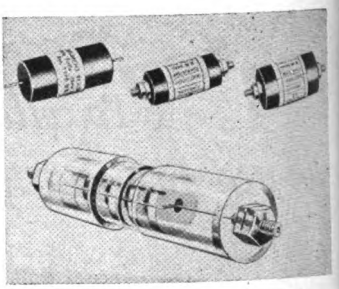


are announced by Daven Co., 191 Central Ave., Newark 4, N. J. These resistors may be employed as secondary standards, resistor elements in bridge networks, in voltage divider circuits and in attenuation networks. Resistor windings are non-inductively wound—in spool or mica-card types. Resistance range—any desired value, maximum 1,600,000 ohms. Four types of resistance wire of different temperature characteristics are available. Accuracy is rated plus or minus 0.1 percent to plus or minus 10.0 percent.

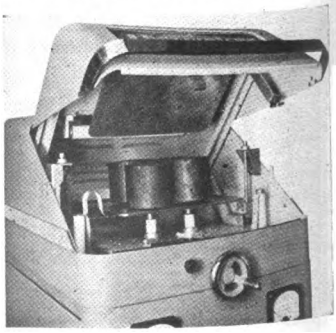
Five new types of hermetically-sealed resistors are available from Instrument Resistors Co., 25 Amity



St., Little Falls, N. J. These types are: RX, SX, WX, CX and BX. CX and BX units have 2-inch No. 18 copper axial leads while the others are equipped with 8-32 threaded studs capable of mounting several lugs, wires or mounting brackets. All units are tropicalized. They provide a range to 1 megohm maximum, and 2 watts maximum. Tolerance is rated 1 percent.

Dielectric Heater

A NEW DIELECTRIC heater, "Heatmaster" for heating plastics, dehydration, sterilization and other purposes has been introduced by the Thermatron Division of the Radio Receptor Co., Inc., 251 West



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QUICK FACTS FOR ELECTRONIC ENGINEERS ABOUT S.S.WHITE FLEXIBLE SHAFTS

S. S. WHITE FLEXIBLE SHAFTS are made in two classes—power drive and remote control—each class specially engineered for its particular type of duty.

POWER DRIVE SHAFTS come in diameters from .043" to .750", with a selection of physical characteristics in the various sizes.

REMOTE CONTROL SHAFTS in diameters from .117" to .437", also with a selection of characteristics in the different diameters.

APPLICATIONS of both classes in radio and other electronic equipment, total millions of feet annually.

A FLEXIBLE CASING is needed with practically every flexible shaft to serve as a runway to prevent "helixing", to protect the shaft and to retain lubricant. S.S.White's comprehensive selection of metallic, fabric-covered and rubber-covered casings, includes a suitable companion casing for every S.S.White shaft and service condition.

S. S. WHITE END FITTINGS for connecting shafts and casings are available in many designs originally developed for numerous actual applications. Hence, they include designs suited to most applications. There is economy in using these standard fittings when practicable.

S. S. WHITE FLEXIBLE SHAFT AND CASING COMBINATIONS

Combinations of selected shafts, casings and end fittings can be supplied in any required length. Although some S.S.White Combinations, such as the tachometer drive, are standard, no combinations are stocked. They are all made to user's specifications. The majority of power drive combinations have been under 10 feet, but many 30-foot combinations, and some up to 50 feet, have operated successfully. Remote control combinations have run up to 80 feet.

COMPLETE FACTS IN THIS 256-PAGE HANDBOOK

This standard handbook-size volume completely covers the subject of flexible shafts. It gives all essential technical data and explains how to select and apply shafts for specific requirements. A copy will be sent free, if you will write for it direct to us on your business letterhead and mention your position.

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

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FLEXIBLE SHAFTS AIRCRAFT ACCESSORIES
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Typical of ERCO'S engineering ability to build completely coordinated Radio Stations is the unit illustrated. Built for Sperry Gyroscope Company, Inc., this equipment unifies a 200-watt radio telephone and telegraph transmitter, three 32-D fixed frequency receivers, one variable frequency receiver, speaker panels and operating position.

Variations of the illustrated console, in any combination of equipment, are available for your own needs. Panel assemblies can be interchanged to any arrangement. Each is replaceable to eliminate obsolescence.

ERCO'S specialized knowledge and technique is reflected in custom-built equipment for such varied users as Pan American Airways, American Airlines, General Motors, Eastman-Kodak, Grumman, Sperry, National Carbon, Westinghouse, and the Hudson's Bay Company.

Whatever your requirements . . . police, airline or industrial; mobile, ground to air, base to branch, office to field . . . ERCO provides complete service in the design, manufacture and installation of equipment that is engineered specifically to meet YOUR needs. We invite your inquiry.

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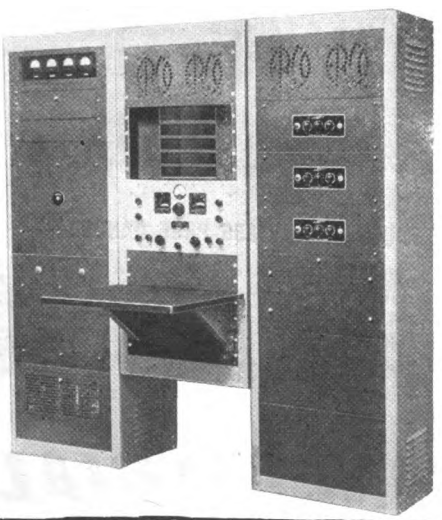


ERCO RADIO LABORATORIES INC

HEMPSTEAD, NEW YORK

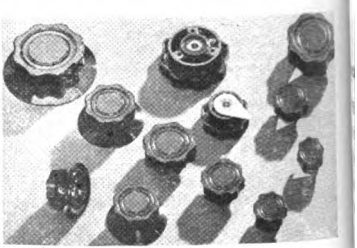
Manufacturers of CUSTOM BUILT RADIO APPARATUS

19th St., New York 11, N. Y. The unit is completely self-contained, and is designed particularly for heavy-duty preheating of plastic molded parts. It is capable of heating a 3.3-lb preform in 1 minute or a 5-lb preform in 90 seconds. Output is rated 5 kw plus; input—approximately 8 kva; line voltage—220 volt, 60 cycle, 3 phase; frequency—30, 15 or 5 Mc; size—24 x 28 x 59 inches high; weight—approximately 1000 lb.

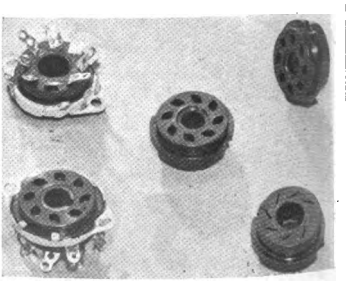
Other Thermatron units are available over a range suitable for almost any purpose. These units are rated at output and include Types K-500, K-1, K-3, K-8, K-15 and K-30.

Durez Molding Compound

THE HARRY DAVIS Molding Company has an extensive line of control knobs molded from Durez plastics and suitable for all standard



requirements. Available in a wide range of styles, the knobs are fluted to permit positive grip for critical calibrations. The Durez plastic used is unaffected by perspiration, greases or oils, is self-insulating, and will not chip or break easily. Illustrated below are National Fabricated Products octal radio sock-



ets, designed to use a minimum of chassis space. Self-aligning contacts float in the Durez plastic insulation and provide the necessary safeguards against fracture of the glass seal of the tube resulting

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from possible misalignment of tube pins. Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y.

Synthetic Insulation

NEW SYNTHETIC insulation called "Flexitube" meets exacting specifications and is suited for use on all wire insulation purposes in radio and communications assemblies. The material has high flexibility, is resistant to abrasion, and has high dielectric strength. At room temperature, Flexitube averages 15,000 volts, with a guaranteed minimum of 12,000 volts for all sizes. Forty-eight hours immersion in tap water results in a reduction of less than 10 percent of its original dielectric strength. The material will not become hard or brittle under temperatures ranging from minus 35 to plus 75 deg C. Walter L. Schott Co., 9306 Santa Monica Blvd., Beverly Hills, Calif.

Speaker

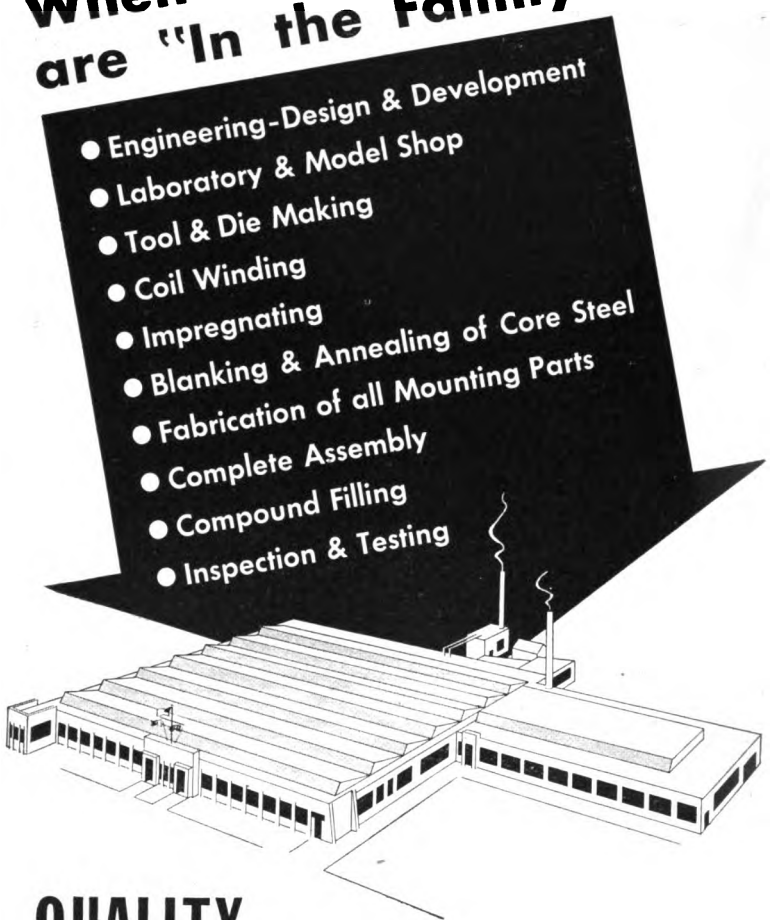
TYPE NF-300 reproducer, originally developed as a talk-back unit in ship intercommunicating systems, is a special-purpose speaker for use in severe weather or difficult operating conditions. Voice coil impedance is 12 ohms, nominal value. Maximum handling capacity for speech is 10 watts. Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago 39, Ill.

Relays

BOTH POTTER & Brumfield Mfg. Co. (Princeton, Ind.) and R-B-M Mfg. Co., (Division of Essex Wire Corp., Logansport, Ind.) announce new relays. The R-B-M is Type 20000 multi-contact relay for minimum operating currents. Contact spring

When all operations are "In the Family"

- Engineering-Design & Development
- Laboratory & Model Shop
- Tool & Die Making
- Coil Winding
- Impregnating
- Blanking & Annealing of Core Steel
- Fabrication of all Mounting Parts
- Complete Assembly
- Compound Filling
- Inspection & Testing



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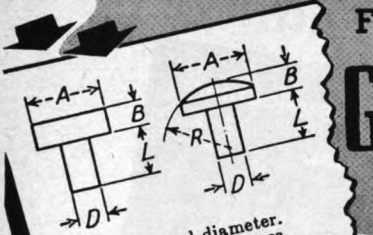
RIVETS ARE A PRACTICAL *and* ECONOMICAL FORM OF Gibsiloy ELECTRICAL CONTACTS



A = Head diameter.
B = Head thickness.
D = Shank diameter.
L = Shank length.
R = Radius of face.

For small and medium sized apparatus requiring low or moderate current, one of the simplest, most convenient and economical forms of contacts to use is the solid contact rivet. It is also generally the least expensive form of contact to assemble. Gibson contact materials most generally used in this form are Fine Silver, Coin Silver and Gibsiloy A, which is a product of powder metallurgy consisting of silver and nickel, possessing a combination of desirable electrical and mechanical properties not obtainable with alloys.

Because contact rivets are used in such large numbers in a wide range of sizes, manufacturers and users have developed a standard for sizes and shapes and recommend its adoption. A list of these standards will be sent on request and without obligation. Write today.

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- Write for our Bulletin No. 431.

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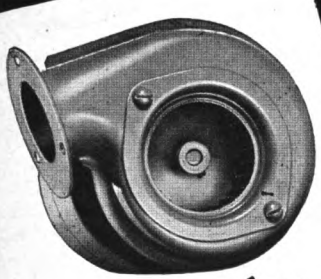
JERSEY CITY 7, N. J.



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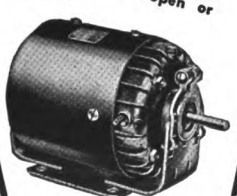

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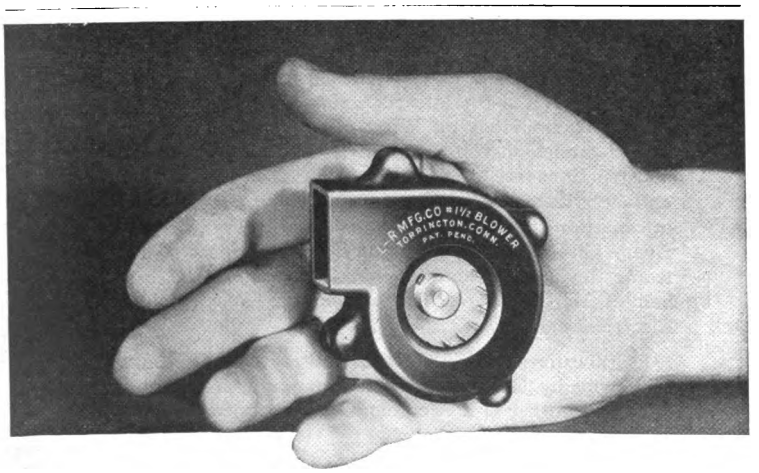

MOVING AIR -- 15 CUBIC FEET A MINUTE ONLY 2½" OF SPACE NEEDED

The blower illustrated, No. 1½*, is one of many blower models manufactured by the L-R Mfg. Div. with C.F.M.'s at 8000 R.P.M. ranging from 15 to 270. These blowers will outperform many larger and heavier types formerly in use and where size and weight are factors, they are the answer to cooling problems presented by electronic tubes or circuit components in airborne communication units as well as in many industrial applications.

*WEIGHT: 2 oz.; CAPACITY: 15 C.F.M. at 8000 R.P.M.; CONSTRUCTION: Housing of high impact phenolic plastic. Wheel is turbo-type cadmium-plated steel; SIZE: 2⅝" long x 61/64" wide x 2½" high.

L-R MANUFACTURING DIVISION OF

The RIPLEY Company

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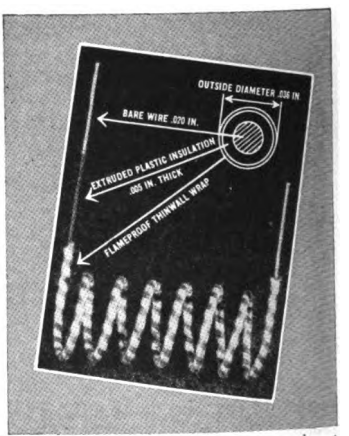
THE WESTERN UNION TELEGRAPH CO.

. . . *installs* SURCO THINWALL WRAP *after Rigid Testing*

. . . . . the first uniformly high quality fine wire, plastic insulated with flame proofed yarn serving.



This photo of typical construction is absolutely unretouched

Voltage Breakdown — 7000 Volts
(For spiraled section shown in photograph after 5 minutes in water)
Insulation Resistance—30 Megs. Per 1000 Ft. at 60°F. (After 72 hrs. in water)

Here are Thinwall's Characteristics: High dielectric properties, Maximum saving in space and weight, Unlimited coding and identification, High temperature operation, Excellent abrasion resistance and toughness, Maximum protection against damage by soldering iron, Unusual flexibility at below freezing temperatures, Flameproof qualities, Good end and spot-stripping characteristics, Low cost.

Surco-American Thinwall Wrap is available in a wide variety of formulations finer sizes of wire and thinner insulations than shown above, for use where maximum performance under specific operating conditions is required.

SURCO PRODUCTS

Surprenant

ELECTRICAL INSULATION CO.

Dept. C 84 Purchase St., Boston 10, Mass.

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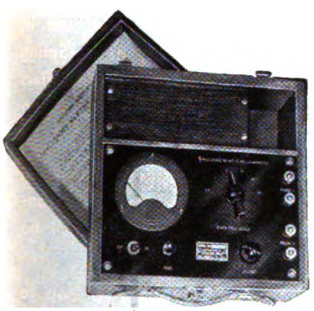
then sleeved over the pin of the phonograph. The pin is slightly reduced in diameter to accommodate the spool. The device saves time in loading a phonograph; enables one to keep pre-selected records together as a unit; prevents marring or scratching of records; and prevents accidental dropping of a record. A special carrying case for extra groups of records (which are held together by the spool) is also available from Mr. Solkover.

Milliohmmeter

MILLIOHMMETER No. 673-F is a new addition to a line of direct reading resistance measuring test

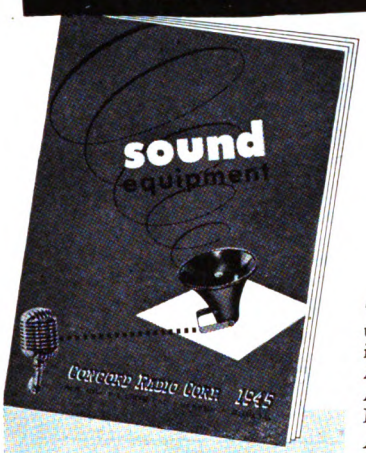


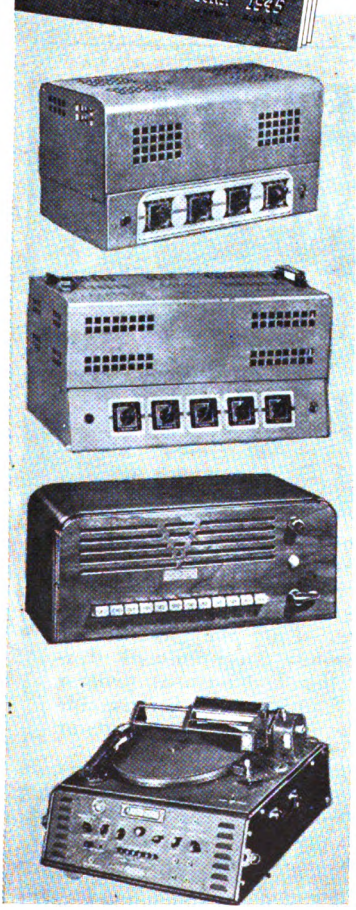
sets produced by the Shallcross Mfg. Co., Collingdale, Pa. The unit has linear scales. The six scales have ranges of: 0, 0.5, 1, 5, 10, 50 and 100 ohms full scale. This range bridges the gap between the regular Shallcross milliohmmeters used for low-resistance testing and the ordinary ohmmeters used for high-resistance measurements.

Headphone Assembly

DESIGNED FOR comfort, efficiency and convenience is this assembly which consists of headphone (or headband) and a microphone. The lightweight, 100-ohm carbon-type microphone comes in a plastic clo-

AMPLIFIERS
INTERCOMS
RECORDERS





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It consists of a high amperage, low voltage transformer with its primary controlled by a trigger switch. To the secondary is connected the combination soldering tip and heating element. The tip is easily replaced and its flexibility permits forming into various shapes to reach difficult connections

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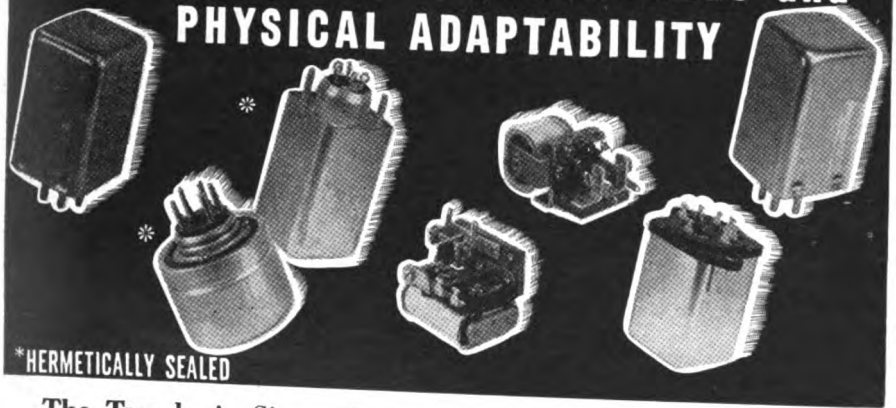

*HERMETICALLY SEALED

The Two basic Sigma Sensitive Relays, Series 4 and Series 5 are available in a wide choice of mounting styles. Type 5 relays have both exceptional sensitivity and extreme ruggedness (withstand 500g. shocks without damage).

Some advanced design features developed for wartime requirements may be unnecessary for peacetime applications. But the wealth of know-how accumulated during the development process will prove of inestimable value in solving your postwar control problems.

Sigma Instruments, INC. SENSITIVE RELAYS

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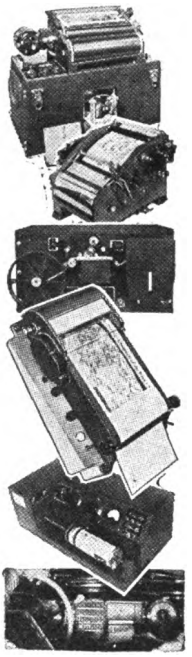

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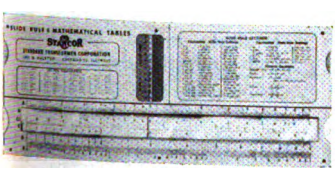

Corp. (1500 N. Halsted, Chicago 22, Ill.) who will sell the rule together with a carrying case at a cost of $1.00. The rule is made of durable stock, clear print and has a transparent plastic indicator.

Literature

GE Literature. Four separate pieces of literature from General Electric Company, Schenectady, N. Y., include: Bulletin GEA-4265 which describes voltmeters, milliammeters and microammeters (types DO-45, DO-46 and DO-55) which are 3½-inch a-c rectifier type electric instruments for panel mountings. Bulletin GEA-4363 describes thickness gages (types A, B and C) which are used to measure thickness of non-mag-

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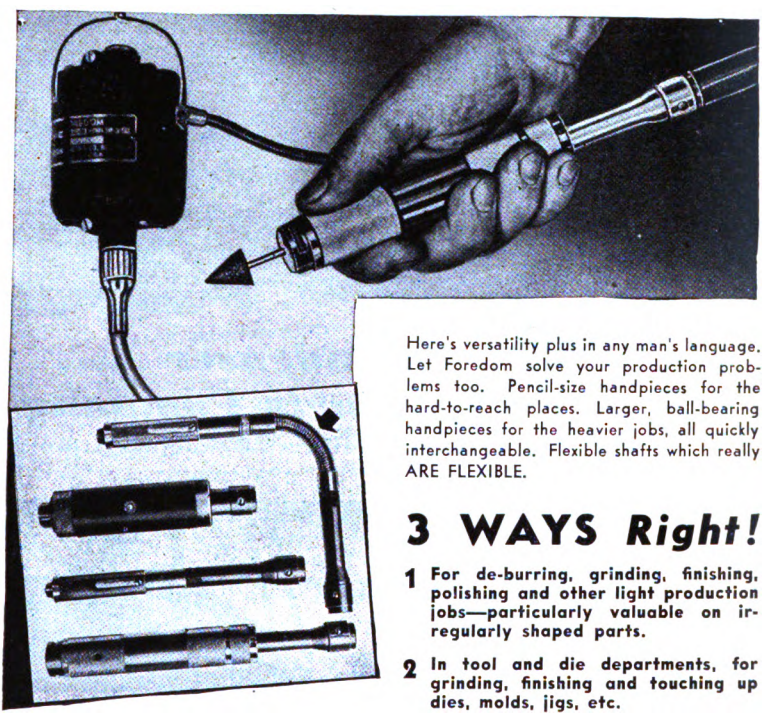

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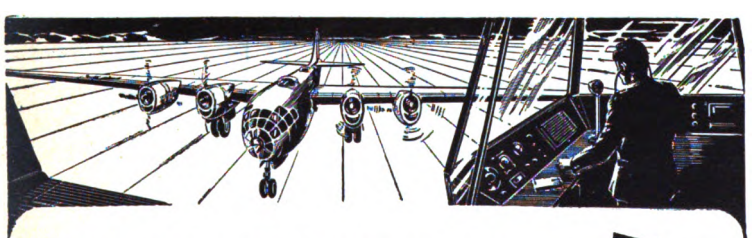

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NEXT MONTH
for announcement of Supreme's new Model 565 Vacuum Tube Voltmeter.

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netic materials. Bulletin GEA-3682B is a 20-page booklet which illustrates and describes sintered-alnico magnets which are compact and permanently stable and are available in a variety of shapes and sizes. The fourth and last Bulletin GEA-4324 describes electric tachometers used to measure rotational speeds from 1 to 60,000 rpm, and linear speeds which can be measured in terms of rpm.

Electronic Heaters. Application of Allis-Chalmers vacuum-tube electronic heaters for both induction heating of metals and dielectric heating of non-metallic materials is explained in a 4-page bulletin, No. B6372, issued by Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

House Organ. Westinghouse Newsfront is the title of a new monthly report on the highlights of Westinghouse Electric Corporation's scientific research, engineering, and production. Vol. 1, No. 1, is available. Write Westinghouse Newsfront, 306 4th Ave., Box 1017, Pittsburgh 30, Pa.

Fastenings. New information has been added on the many types of self-tapping screws, socket screws, and other fastening devices in a new edition of Parker-Kalon's Fastening Catalog Data Book. 204 Varick St., New York 14, N. Y.

Radio Components. A Partial Directory of Radio Components is the title of a 4-page bulletin which lists 500 different items in 30 classifications as manufactured by the Alden Products Co., 117 N. Main St., Brockton 64, Mass.

Liquid Polystyrene. A new technical bulletin contains data on the dielectric constant, power and loss factors, as well as electronic characteristics of No. 912 Polyweld (a pure polystyrene in solution form). American Phenolic Corp., 1830 South 54th Ave., Chicago 50, Ill.

Cable Accessories. Bulletin No. 25-A is a 4-page folder which illustrates and describes cable accessories from Andrew Co., 363 East 75th St., Chicago 19, Ill.

MEMO

To: MR. MANUFACTURER
c.c. MR. SALES MANAGER
c.c. MR. CHIEF ENGINEER

From: ATLANTIC ENGINEERING PRODUCTS

Subject: POST-WAR SALES ENGINEERING

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Miscellanea Vol. XIX, No. 10 of The General Radio Experimenter contains the following articles: "High-Frequency Compensation for Amplifiers," "Dynamic Balancing in the Field with the Aid of a Stroboscope," "The Use of Variacs at Voltages Above 230" and "Rubber Glove Tester Uses Variac." General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Tube Manual. A new 1945 Catalog and Manual, available for 25 cents, contains information on all tubes manufactured by Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago 47, Ill. Some 22 pages of the manual are devoted entirely to tube characteristics, and a large portion of the catalog contains technical information on transmitters and tubes.

Reference List of Tube Types. To assist design engineers in the selection of tubes for specific applications there is available a handy "pin up" chart of recommended tube types. Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.

Plastic Molding. A 16-page booklet entitled "A Businessman's Guide to the Molding of Plastics" contains charts and photographs. A good portion of the booklet deals with material selection, design, mold-making, and production. Also contained in the booklet is data on the facilities, equipment and the production capacity of Kurz-Kasch, Inc., Dept. 7G, 1415 S. Broadway, Dayton 1, Ohio.

Replacement Capacitor Catalog. Catalog No. 195 contains complete data on capacitances, sizes and prices of Cornell-Dubilier (South Plainfield, N. J.) electrolytic capacitors.

Industrial Sound. A 66-page pamphlet has been compiled giving a comprehensive picture of the installation and most efficient use of equipment for transmitting sound as an operational and morale item in war plants. The title of the pamphlet is "Guide to Industrial Sound." It is sponsored by The Industry Advisory Committee for Industrial Sound Equipment and The

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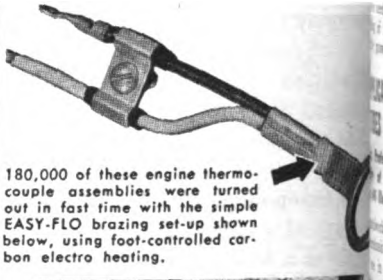

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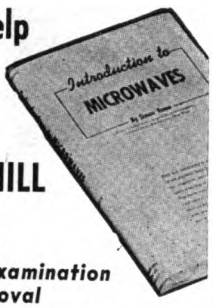

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By Dr. Simon Ramo, *General Electric Company; Union College, Schenectady, N. Y.* 135 pages, 5¼ x 8¼, $1.75.

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By W. D. Cockrell, *Industrial Engineering Divisions, General Electric Co.* 247 pages, 175 illustrations, charts, and tables, $2.50.

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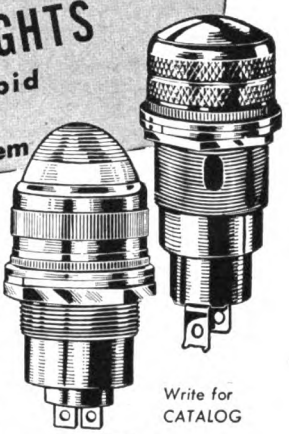

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Radio and Radar Division of the War Production Board and is available for 15 cents from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

Resistors. Koolohm type resistors having the "tropicalized"-glazed outer protective shell and new type of moisture-proof end seals are described in a new catalog which also contains data on 5, 10, 25, 50 and 120-watt fixed types, as well as 10-watt adjustable types. Sprague Products Co., North Adams, Mass.

Tropicalized Wax. This 6-page folder discusses tropicalized wax (fungus resistant) and tells about results of tests made on this manufacturer's products. Four pages of the folder show illustrations of Agar test plates of wax heated at 250 deg F. Zophar Mills, Inc., 112 26th St., Brooklyn 32, N. Y.

Research Institute of America. "Rehiring Your Company's Veterans" is the title of a recent Research Institute analysis on the subject. The booklet is timely and authoritative and tends to answer most of the questions pertaining to veterans employment or re-employment. It is an analysis which every employer should read. Four chapters of particular interest are "Your Rehiring Obligations Under the Law," "Where to Get Help in Retraining Veterans," "The Meaning of Changed Circumstances," and "Solving Seniority Questions." Copies may be obtained by writing the Public Relations Dept., Research Institute of America, 292 Madison Ave., New York 17, N. Y.

Electronic Controls. Bulletin No. Z6300 (supersedes Bulletin No. Z6200) is a 12-page bulletin which contains a condensed listing of electronic controls available from Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 1, Ill.

Silicon Steels. Core loss data, magnetization curves and permeability curves are given in a new technical bulletin which confines itself to brief essential data on the several grades of Republic silicon steels most generally used at this time. The bulletin is prepared

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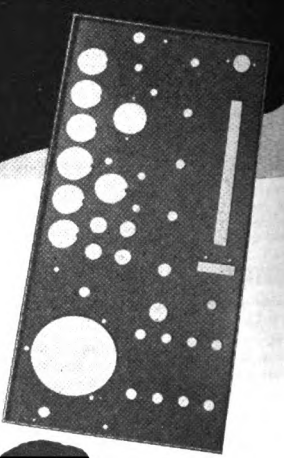

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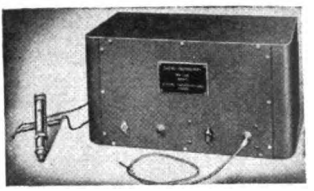

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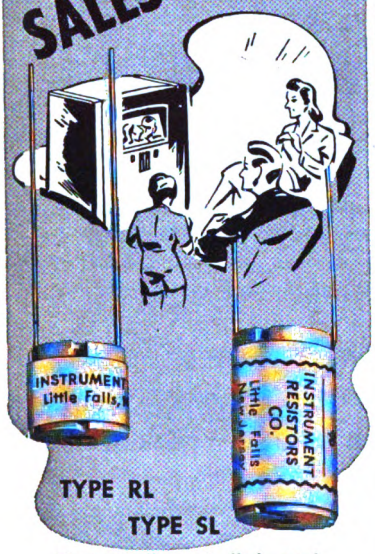

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for the electrical manufacturing industry and is available from Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio.

Induction Heating. Two separate booklets available on this subject include a reprint from *The Iron Age* entitled "Induction Heating, A History of Its Development" and Bulletin No. 25 entitled "Induction Heating & Melting in Industry." This 28-page booklet contains illustrations and descriptive data on equipment available from Ajax Electrothermic Corp. Ajax Park, Trenton 5, N. J.

Background Data. Alden Products Company (117 North Main St., Brockton 64, Mass.) have issued a 44-page, nicely bound catalog which tells about their facilities for designing, engineering and manufacturing complete sub-assembles and items difficult to obtain. The booklet contains many illustrations.

Radio Parts. Catalog No. U.C.-44 has been prepared essentially to provide the buyer of Utah parts with all of the important technical data pertaining to these products. The catalog is spiral bound and contains 50 pages of illustration and descriptive matter. Utah Radio Products Co., 812-20 Orleans St., Chicago 10, Ill.

X-Ray Diffraction. "X-Ray Diffraction Apparatus and Applications" is the title of a 26-page booklet (Bulletin No. 1245) which contains a section devoted to the application of x-ray diffraction and gives typical diffraction radiographs and their interpretation. Picker X-ray Corp., 300 Fourth Ave., New York, N. Y.

Selenium Rectifiers. Bulletin No. RDP-107 is intended primarily for design engineers who use rectifiers or other sources of direct current in their products. It is an engineering manual and gives standard element specifications. Fansteel Metallurgical Corp., Rectifier Div., North Chicago, Ill.

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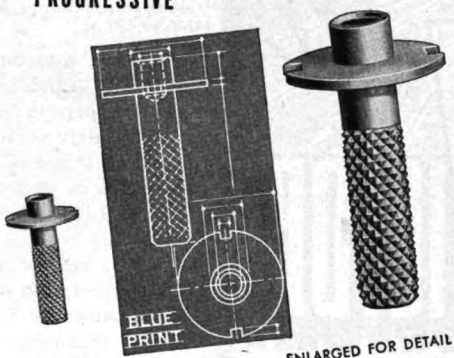

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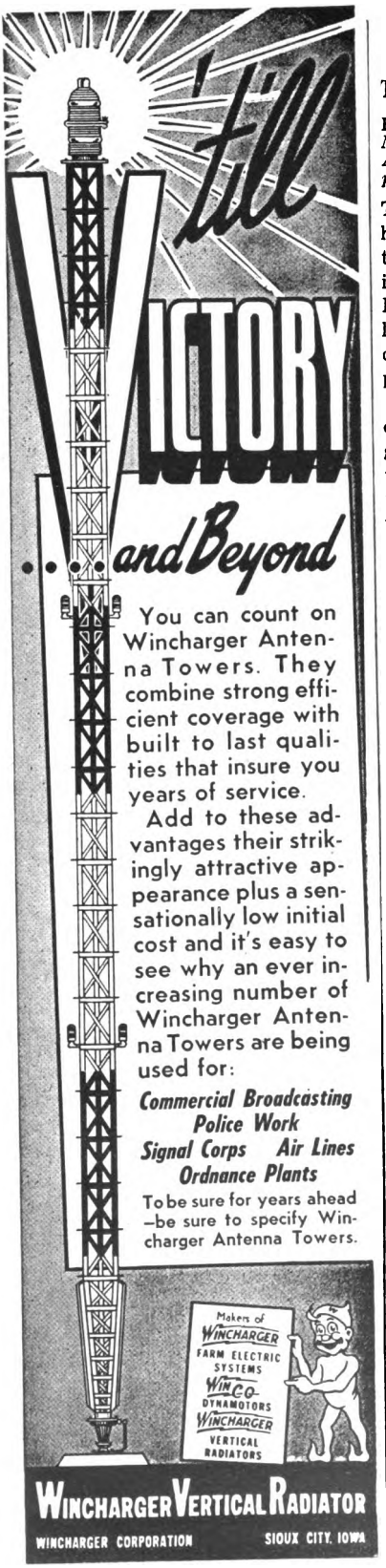

NEW BOOKS

The Soul of Amber

By ALFRED M. STILL. *Published by Murray Hill Books, Inc., 232 Madison Ave., New York, N. Y., 1944. 274 pages, $2.50.*

THIS BOOK WILL NEVER achieve the heights of popularity held forth by the publishers in the jacket because it is definitely not a "popular" book. However, it is a contribution to the literature on electrical science that could easily become of major importance.

It is a review of practically all of the great, and most of the near-great, names in the history of electricity, including what they contributed to electrical science and what they thought. As such it is of definite value to anyone interested in the background of electricity and electronics. The author has performed a monumental piece of work. He has read, digested and evaluated an incredible amount of literature that deals with the personalities behind electrical engineering down through the ages.

The name of the book is inaccurate, in a sense, because the soul of amber is electricity or an electrical charge. Amber as such is discussed only briefly. It would seem that the title was chosen for popular appeal when the text does not live up to that appeal. Actually, this book would make dull reading for anyone not interested in electricity and the development of this "art" as we know it today.

There are some errors of omission that seem to be serious, whether or not they are intentional. Nothing is said about the contributions of Edison and Tesla. Steinmetz is covered only briefly. Westinghouse and William Stanley are given all the credit for developing alternating current to the point where it was practical, even though Westinghouse paid Tesla $1,000,000 for his patents. None of the living electrical scientists are mentioned at all. Conversely, what seems like an inordinate amount of space is devoted to Faraday, Eddington and others who although they are important seem to have been emphasized too much.

Two indices are provided—one of names and the other of subjects. Both could be considerably ex-

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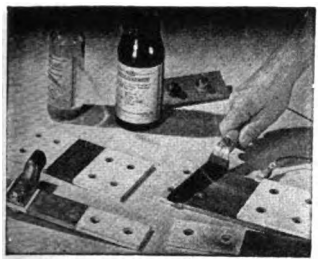

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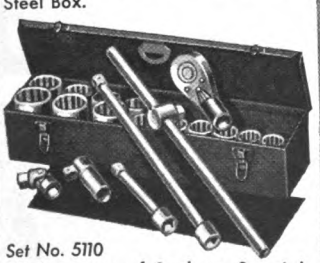

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panded to make the book of greater value to those who want more detail. There is also a too-short chronological table of key dates in the progress of electrical science. Just in passing, it would be interesting to know why the dates for the first steam locomotive and Fulton's steamboat are included in this table.—K.S.P.

• • •

Plastics in Practice

By JOHN SASSO and MICHAEL A. BROWN, JR. *Published by McGraw-Hill Book Co., 330 West 42nd Street, New York 18, N. Y., 1945 185 pages, $4.00*

MORE THAN one-half the total poundage of molded and laminated plastics goes into parts and assemblies associated with electrical circuits. Because electronics is a relatively new science, it is only natural that a good portion of this poundage should be found in electronic applications. In effect a handbook of plastic applications, this book offers much of interest to electronic engineers, especially if they are concerned with the development, design or production of components of electronic equipment.

The book consists of a collection of successful case histories of designs of over 100 plastic parts of all kinds. Each application described is covered from all standpoints. In fact, the treatment is such that the specific application is merely a peg on which to hang a discussion of the whys and wherefores of applications of plastics in various fields or for various purposes. In this respect the book is unique in industrial publishing.

Many of the case histories are of direct interest to the electronics field, particularly in view of their background discussions. These include circuit-breaker handle, cold-molded heater plug, standoff insulator, radio cabinets, electrical controller, radio-tube base, fence-control housing, microswitch, cable insulation, molded capacitor, ignition distributor head, name plates, nonmetallic gears, double injection molding, coaxial cable, heat-resistant styrene thermoplastic, styrene elastomer, thermosetting copolymer and silicone resins.

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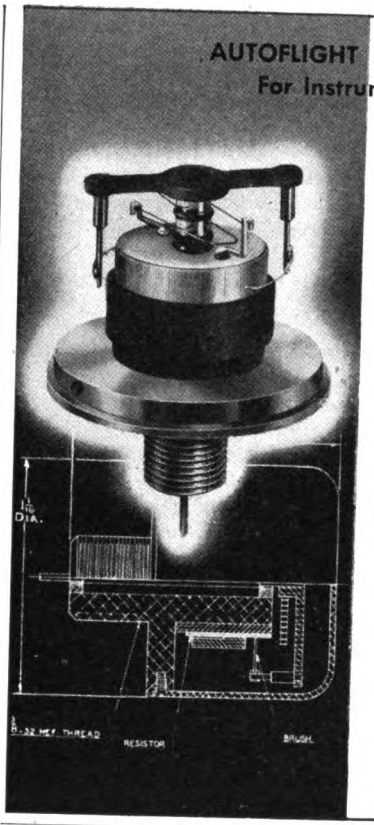

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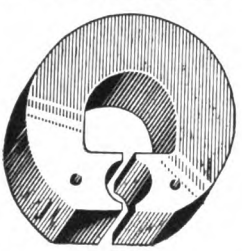

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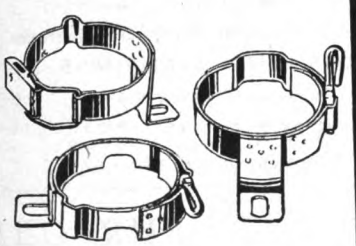

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the various plastic materials, methods of forming, comparative properties, important design considerations and cost factors. Both of the authors have given plastics a good part of their attention for many years and are well-known in this field. The book reflects their wide interests and activities. It should be a valuable aid to any engineer who is interested in plastics.—K.S.P.

• • •

Production-Line Technique

By RICHARD MUTHER. *McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y., 1944, 320 pages, $3.50.*

THE NECESSITY FOR turning out large quantities of precision equipment at a fast rate for the armed services forced many companies to turn to line production from job-lot manufacture. The success of this change has been apparent for some time, although at the start it was doubtful whether or not many types of equipment could be produced in this way.

There are certain fundamentals common to all production-line methods. If these fundamentals are thoroughly understood there should be little difficulty in applying such methods wherever they can economically be used. This book, then, was written expressly for industrial executives who are considering the use of line production. It pictures the current state of this art as found in well-established organizations after a two-year study to gain first-hand information. In particular, the book was written for medium-sized plants, which have always been the accepted domain of job-lot manufacture.

Four general sections are provided—advantages and limitations of line production, establishing the line, operating the line and diversification in line production. A chapter of problems is included to help the reader become familiar with production-line techniques.

Manufacturers of electronic equipment all the way from simple parts to complicated assemblies could make good use of this book by studying it to determine whether or not their products are applicable to line production. The final answer may not always be readily apparent, but if the book stimulates thinking along the proper lines it will have served its purpose.—K.S.P.

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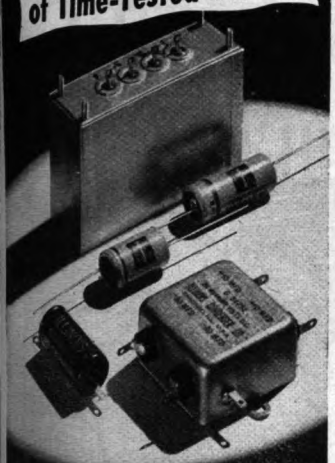

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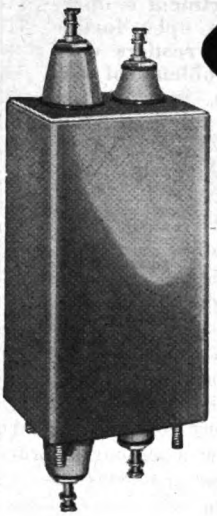

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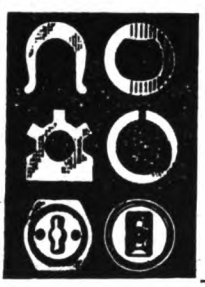

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published

Dangerous Art

Dear Mr. Henney:

I READ ELECTRONICS pretty carefully, including the advertisements which are a great source of information. Two recent full-page advertisements by commercial organizations have set me thinking about safety. We are all safety conscious, and I am especially so since our laboratories here necessarily must be as safe as possible. Of course, some risk is inevitable.

But to get on: In one ad, the caption reads that the specialist is giving a capacitor a thorough ". . . voltage and capacitance checking." With his right hand the operator practically touches the *hot* side of a transmitting capacitor presumably being tested at several thousand volts; with the left hand he applies the power to the circuit! A perfect arrangement for a serious accident.

The photograph of the testing of a vacuum capacitor in another issue is a second case in point. From the sphere-gap it is evident that the capacitor is being tested at a rather high voltage; one hand of the operator is on the hot circuit and the other on the power switch.

I feel that these examples of unsafe testing methods represent a low order of engineering and should not be given the widespread publicity which their publication in ELECTRONICS will ensure.

P. M. HONNELL
Lieut. Colonel, S.C.
O-I-C of Laboratories
Dept. of Chemistry and Electricity
United States Military Academy
West Point, N. Y.

• • •

About the Format

Dear Sirs:

ON RECEIVING my November 1944 issue of your publication I was astonished and delighted to find that you had led the way back to common sense in the arrangement of your articles so that one could read the whole article without the irri-

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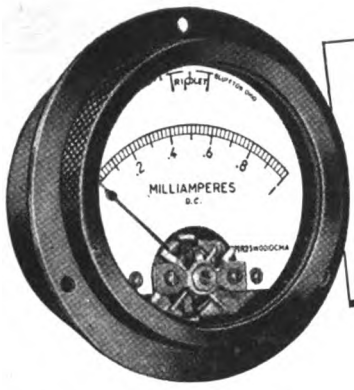

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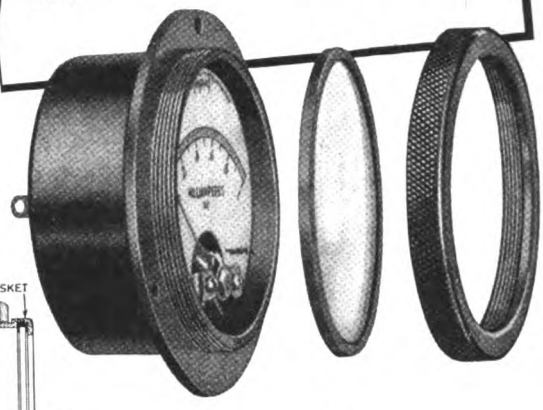

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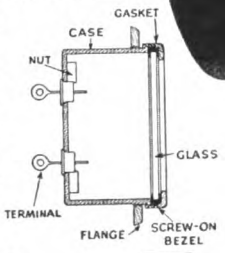

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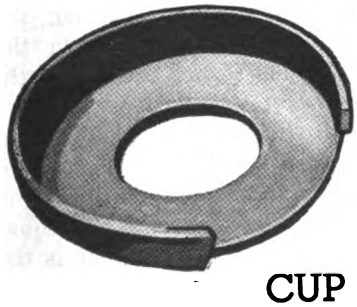

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tating need to chase the tail ends through endless hide-outs in the back pages.

The fashion of insulting the authors of the articles and the readers thereof is very widespread in American technical and trade journals and causes constant irritation to those who are interested enough to pursue the elusive "rest of the article." Apart from this it is also self-derogatory, as if the editors said actually "This is the only part worth reading; if you *must* read the rest, sort it out for your self—it's somewhere in the back of the number." Then begins the schoolboy prank "Turn to page 163" etc., etc. *ad nauseum.*

You have shown now that the articles *can* be arranged in intelligent consecutive fashion, at the expense of a little thought (and possibly some sub-editing) and I am sure the majority of your readers will appreciate the compliment as much as I do.

For those of us who endeavor to maintain files of reference for particular subjects, the added simplicity saves a lot of cross referencing between files to indicate the whereabouts of a page containing the tagends of two or more articles on separate subjects. In some cases this involves typing the rest of an article to complete the file record.

I offer my sincere thanks for the saving of time and patience, and the added pleasure of reading the subject matter.

V. HARDING
Wing Commander
Technical Branch
Royal Australian Air Force

• • •

Cathode Followers

Dear Mr. Skeeters:

ACCORDING TO your last letter, (ELECTRONICS, May 1945) I see that you are misinterpreting the end results of my article in the October 1944 issue, entitled Cathode Follower Calculations.

If you will study the article carefully you will notice that there are two impedances mentioned; one is the output impedance, Z out, equations 8 and 9, and the other is the internal impedance of the cathode follower, Z_i, equations 10 and 11. The former is the parallel combination of R_k (the cathode resistor) and Z_i (the internal impedance).

Therefore, as you can see, the

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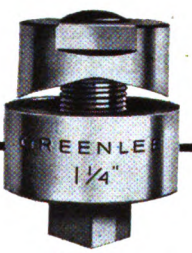

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effect of the cathode resistor is not neglected in the solution for the output impedance, and the only assumption made is that μ is very much larger than 1.

HUMBERT P. PACINI
Wanamassa, N. J.

• • •

Accentuate the Positive

Dear Sirs:

THERE IS AN ERROR in Fig. 5 on page 143 of the May 1945 issue. The large circle represents *maximum* voltage across C_2 instead of *minimum* voltage across C_2. Although this is rather obvious from the text, I thought you would like it called to your attention.

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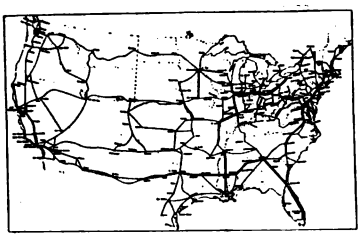
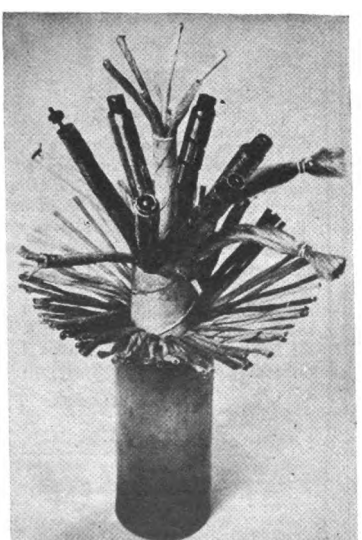


Interim report shows status of Bell Telephone coaxialization program in map above where heavy solid line represents cable installed or in process up to the end of 1945, dotted line shows remainder of 5-year program and fine solid line marks existing major toll lines of the system. The end of 1945 is expected to see 2000 miles of the cable (as shown below in full flower) manufactured, and at least 75 percent of it in the ground



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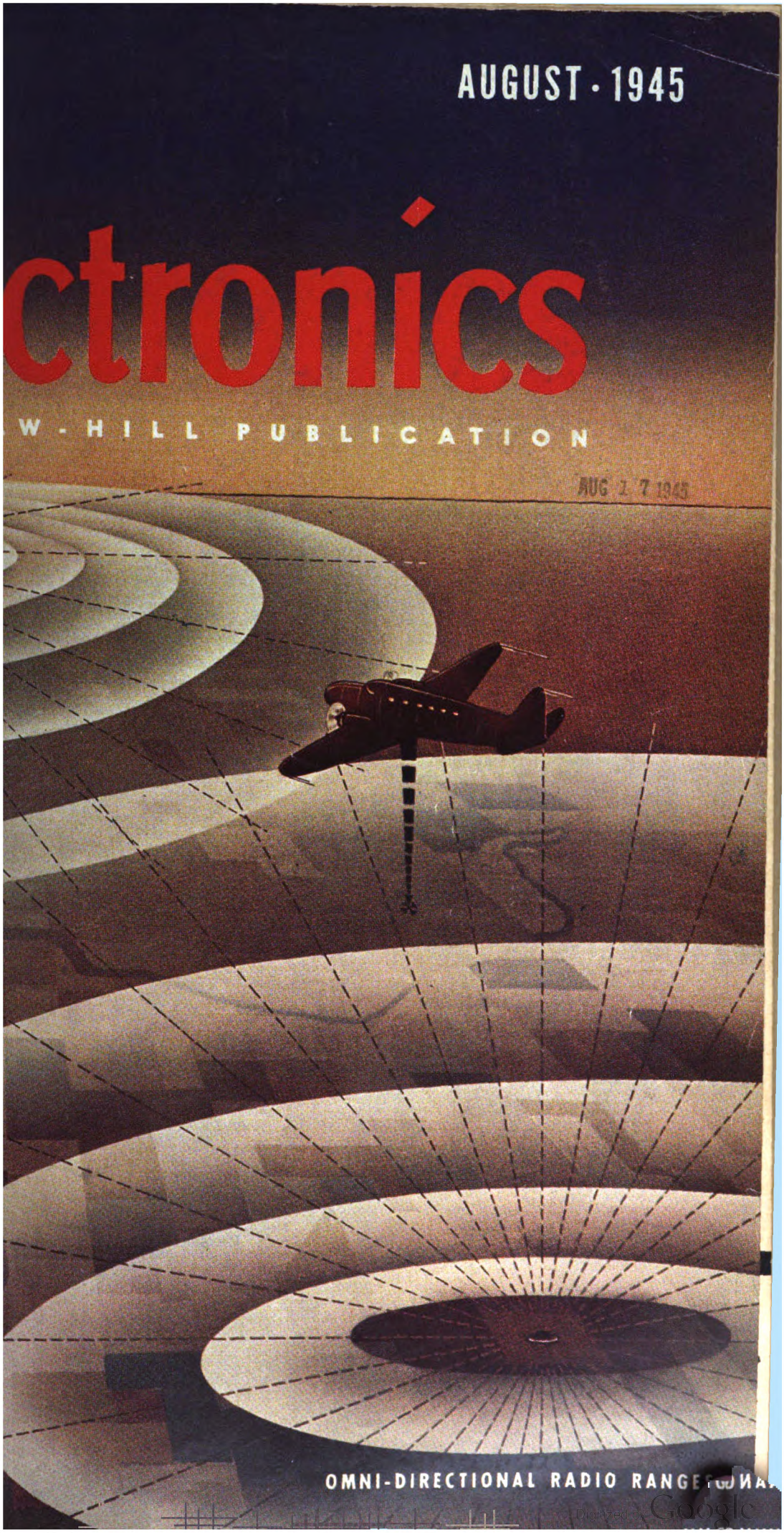

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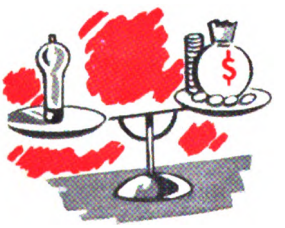

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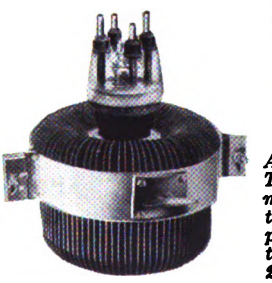

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CROSS TALK

▶**RADAR** . . . Partial lifting of the blackout regarding radar—probably the war's greatest development—reveals that the fundamental principles and much of the detail are what any well-equipped engineer would dope out for himself. Two natural phenomena underlie all radar apparatus (1) Radio waves travel at a finite velocity of approximately 1000 feet per microsecond, (2) Radio waves striking a conductor or semiconductor cause currents to flow in that conductor and these currents cause a re-radiation of energy some of which, in the form of an echo, returns to the radar site. Add to these phenomena the ability of engineers to direct radio energy in sharp beams, their penchant for producing enormous degrees of voltage amplification, and elegant methods of measuring time to fractions of a microsecond, and you have radar.

In practice, high-powered (hundreds and even thousands of kilowatts) pulses of energy are sprayed over chosen sectors of space surrounding the radar transmitter. At the time the pulse is sent out, a stream of electrons starts to move across, or around, or in some other direction over the screen of a cathode-ray tube. When the echo returns, a deflection of this beam of electrons indicates the time of arrival by the spacial displacement of a pip from the start of the impulse.

Long range, early warning, radars must perforce operate on fairly long waves, 100 megacycles or so, and the radiating structures are correspondingly large to secure highly directive beams. Short range sets can operate on the microwaves (thousands of megacycles) and the antennas can be very small and still quite directional. The entire equipment can be compact and yet sufficiently powerful during the pulse time so that even mobile units can perform magnificently in active service.

Radar may be compared to older acoustic methods of plane detection in the following manner. The time of transit, out to the target and back, is some fraction or multiple of 500 feet per microsecond, approximately. On the other hand, sound waves travel in air at the rate of 1100 feet per second. Radar will detect a plane as far off as 100 miles. Acoustic methods are doing pretty well if they detect a plane at, say, 25 miles. At 1100 feet per second, the sound from the plane will arrive at the detector site in about 2 minutes. The detector, therefore, tells the operator not where the plane is but where it has been. In the time required for the sound of the plane to reach the detector, a 360-mph plane will have cut in half its distance when it was detected.

Acoustic methods are virtually outmoded by the increased speed with which planes travel.

The radar principles—accurate measurement of time, pulse transmission, high directivity—may be used for purposes other than the location of targets in the air or on the surface of the land or sea. But these other uses remain behind the veil of military secrecy. Some of the applications are exceedingly interesting and effective in weapons of war and will go a long way toward justifying the belief that the peacetime age to come will really be electronic.

▶**TUBES** . . . To an extent few of us realize, this scientific war we are waging depends upon vacuum tubes. One of the remarkable aspects of this fact is that millions and millions of tubes are serving under conditions for which they were not designed or manufactured. These millions of tubes are ordinary receiving tubes selling for a dollar or less in the home market. Designed for sedentary jobs, they now serve in tanks, on man's back, in submarines, on warships, in planes and in other places where the rigors of shock, vibration, temperature or electrical overload must cause the tubes to wonder how they ever got into such situations.

For years industrial engineers were skeptical about electronic apparatus because the tubes were too fragile. Wartime experience indicates that tubes do stand up when the apparatus in which they work is properly shock-mounted. In industrial plants, a routine of testing and replacing tubes on regular schedule —before trouble occurs—should eliminate all difficulties from fragility.

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SURPLUS EQUIPMENT

The government has set up machinery by which military radio and other electronic equipment may be marketed through regular trade channels by manufacturers. Details of the plan are given here, together with the latest news relative to its operation

By G. T. MONTGOMERY
Washington Editor

SURPLUS radio and electronic equipment is already moving into the market in sufficient quantities to indicate the policy that the government intends to pursue in such disposals.

Under the provisions of the Surplus Property Act of 1944, the Reconstruction Finance Corporation is responsible for the disposal of capital and producer goods, which will take in the bulk of electronic surpluses.* This agency, with one of its subsidiary corporations, the Defense Supplies Corporation, intends to work closely with manufacturers rather than to conduct sales on an "as is, where is" basis. It believes that the unloading of surplus should be a jointly sponsored and jointly conducted program in order to give maximum advantages to both government and industry.

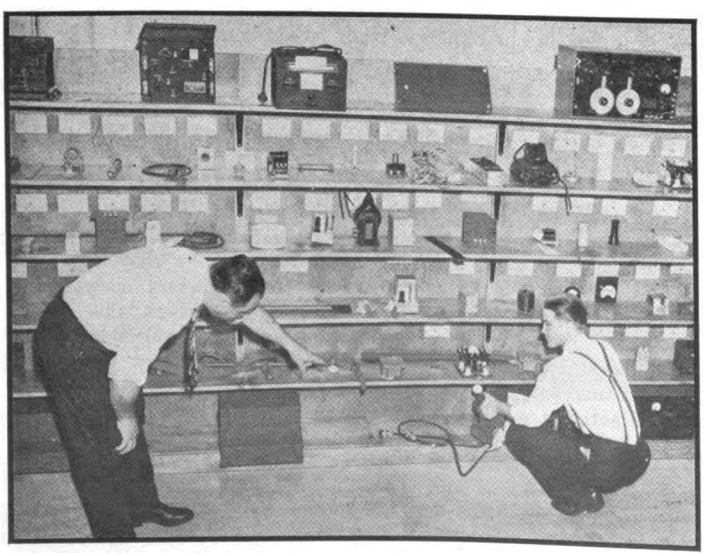
Every effort will be made to stabilize the price structure, which means no dumping of surpluses on the market and no harmful bargains. Surplus must move through legitimate channels at legitimate market prices. When the equipment has little or no market value, RFC plans to pursue a bold policy of scrapping it. Unless there is some definite use in mind, material will not be stored with the hope that someday a use will be found for it. For example, such will be the case with certain parts of Signal Corps high-frequency electronic equipment.

Reports of surplus radio and electronic equipment and components are received by RFC from two main sources:

(1) Depots and warehouses of Owning Agencies, i.e., Army, Navy, Maritime Commission, OSRD, etc.

(2) Plants of contractors whose contracts have been terminated, in which event the Owning Agencies have taken title to unused material purchased for the terminated contract.

*Department of Commerce handles surplus consumer goods, which includes home radio receivers.



Display of surplus parts and complete units at a central redistribution point

Surplus Equipment Sources

In the case of surplus located in depots and warehouses, a formal report of surplus is made to RFC. On the basis of this report, orders are given to the Owning Agency to ship the material declared surplus to an RFC manufacturer-agent. Simultaneously, the manufacturer-agent is notified that the shipment is on its way.

In the case of material which is excess to the needs of a contractor whose contract has been terminated, RFC is notified of the surplus inventory as soon as the inventory has been compiled. Instructions are then given to the Termination Officer to have the material shipped directly from the contractor's plant to an RFC manufacturer-agent. The formal declaration of surplus is made upon the basis of the quantities actually shipped.

A short cut has been effected in the procedure for shipment of termination inventories by having them shipped prior to formal declaration of surplus, thereby expediting clearance of the contractor's plant. As an example, while this reporter was sitting in the office of an RFC official, an Army Termination Officer phoned that in a certain plant a large contract

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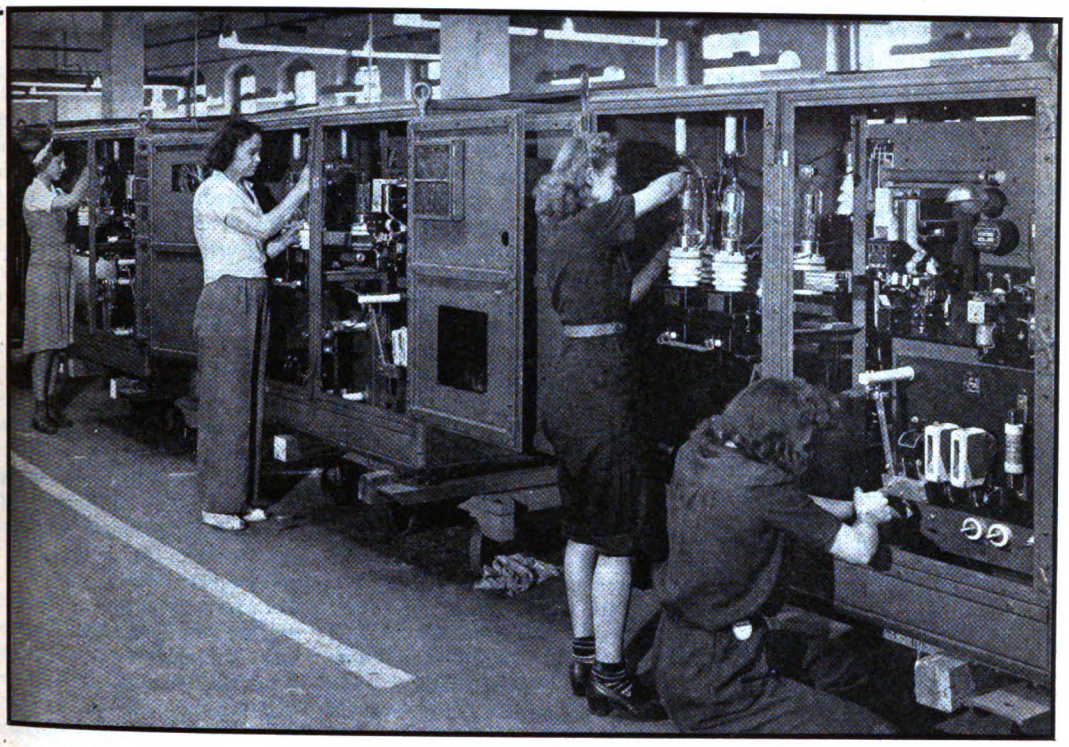
DISPOSAL PLAN



Military electronic equipment is modified in a Defense Supplies Corporation plant to meet commercial needs

termination had occurred and the Army had acquired title to large quantities of resistors, capacitors, tubes, etc. Parts valued at $100,000 were ready for packing and shipping to manufacturer-agents and manpower was available for the packing. In order to save time, permission was given by the RFC official to ship this portion of the stock from the contractor's plant to parts manufacturers for immediate re-sale, subject to clearance of necessary documents later. Since then the full termination inventory, composed of a listing of 68 pages of surplus parts, has been received by RFC.

Conditions Governing Sale

Regardless of the source of the surplus material, the RFC manufacturer-agent receives a copy of the shipping order, which serves as his notice of the pending arrival of the material. When material actually arrives, he takes it into the inventory which he is holding as agent of the RFC. He acknowledges receipt of the material by signing a copy of the original shipping order. He then inspects and tests the material to determine whether it is suitable for

(a) Filling military orders
(b) Filling civilian orders
(c) Repair or modification
(d) Scrap

After this classification has been made, he lists it for sale, provided it falls in Classes (a) or (b). If it falls in Classes (c) or (d), he is requested to submit to RFC his recommendation as to whether the material should be reworked, setting out his estimate of the cost of reworking and the price at which it can be sold after reworking. If he thinks the material should be scrapped, he is required to so state to RFC in order to receive formal approval for physical scrapping.

Material of a standard nature, i.e., comparable to that which the manufacturer normally sells, can be sold as a part of his regular stock. In fact, under the Agency Agreement, the manufacturer agrees that when filling orders he will include a certain percentage of the surplus stock which RFC is asking him to liquidate. Thus, the manufacturer is acting as an agent of the government on a commission basis.

In the case of a military order, the manufacturer must fill the order first from surplus stock, if possible. For instance, if the Signal Corps ships tubes to a tube manufacturer and the manufacturer at some later date gets an order from the Navy for these same tubes, the manufacturer must use the surplus tubes as far as they will go before he starts to fill the order from his own production. To give a concrete example, one manufacturer-agent had $96,000 worth of capaci-

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tors shipped to him as surplus. Shortly thereafter, he received a military order for $20,000 worth of the same capacitors. The order had to be filled from the surplus stock.

Guarantees and Prices

Under the Agency Agreement, the manufacturer is permitted to sell surplus material with the same warranty that applies in his commercial sales. Hence a purchaser knows that when buying surplus electronic material he has the same assurance as in any other purchases which he regularly makes from that supplier.

If the material is non-standard, the manufacturer-agent may send out a special catalog and flyers to his customers, listing the material which he has to offer. Prices on nonstandard material may vary from regularly published price lists. It is necessary for the manufacturer to recommend prices which, from his knowledge of the market and potential uses, will represent a fair price to the government and to the customer. All such prices are subject to price approval by RFC.

The manufacturers receive the commission provided in the contract and any purchaser makes his normal margin of profit, with the chance of profiteering normally inherent in surplus dealing minimized.

Although minimum quantities of material which will be sent to manufacturer-agents have been established (based on the economy of handling), often relatively small quantities are shipped because it is felt that the manufacturer-agent will receive comparable items from other sources and by combining the various small quantities he may make a regular offering of the combined total. The undesirable alternative would be to offer odd lots at give-away prices.

Many Manufacturers Participating

Defense Supplies Corporation, acting for RFC, has signed over 200 manufacturers to act as agents for disposal of surplus. What happens to surplus in plants where the owners have not signed the Agency-Agreement?

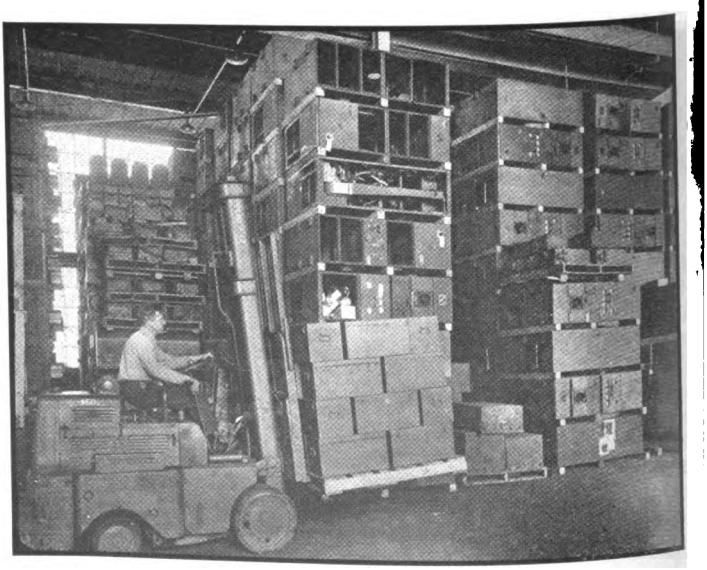
Let us say that there are 25 manufacturers of a certain component. Ten manufacturers are interested in handling their own surplus, while 15 are not. An effort is made by DSC to get one of the ten to take over the other manufacturers' surplus, since he has the proper equipment for testing it. In case none of the ten want it, the surplus, if useable, is turned over to a central agent, who adds such items to his business. (To date, 15 companies have agreed to take end-equipment and component parts other than their own.)

Some manufacturers want to be rid of surplus so they can get ready for postwar competition as soon as possible. They fear that there will be an avalanche of a wide variety of items and they do not want it on their shelves. Others feel that their normal outlets for peacetime products do not lend themselves to the sale of specialized products. Still others are too busy with war work to enter into a program of this nature at this time, but plan to do so as soon as possible. Regardless of the reason, RFC is proceeding with its program to dispose of all surplus electronic items under the plan described, no matter who the manufacturers may have been.

The Reconstruction Finance Corporation believes that a substantial percentage of the electronic equipment declared surplus, although originally designed for military purposes, can be sold by manufacturer-agents without modification. In all instances such equipment must be repaired and missing parts supplied. Examples of equipment of this nature are aircraft transmitters and receivers suitable for commercial operation, vehicular equipment of types desired for police or dispatching purposes, and small marine equipment. A relatively small quantity of such equipment has already been tested, repaired and sold.

Types of Gear Available

There will obviously also be large quantities of equipment and components which were designed for such specialized military applications that no commercial outlet is likely to be found for them in their present form. In these instances engineering surveys by manufacturer-agents will develop any modifications which can be economically made to adapt the units for civilian usage. An example is the redesign and modification of interphone equipment previously used in Army tanks. The present redesign involves the elimination of the microphone and the headset which are not at present available in surplus stocks and the substi-



Declassified Signal Corps high-frequency apparatus

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tution of a speaker system for this purpose. Testing of the market has disclosed that the redesigned unit will sell at a price which exceeds the best "as is" sale price by substantially more than the cost of modification.

Another instance of desirable modification has arisen in connection with the declaration by the services that a very large quantity of two models of obsolete Signal Corps equipment are no longer required. Because of the bulk of the equipment and the tactical purposes for which it was designed, it was immediately apparent that it could have no useful civilian application. However, engineering surveys disclosed, especially in the case of one model, that many of the major sub-assemblies could be sold "as is" or with modification for industrial or scientific uses. The transmitter, which cannot be used for ordinary broadcasting, may be adaptable for use as an electronic heating set, according to officials. The electronic rectifier may be saleable as such. Parts may be useable, with changes, as test equipment. On the other hand, two receiver units would have to be extensively modified for conventional uses, if they are to be useable at all.

Rectifiers Come First

The first units to go on the market are electronic rectifiers, of which there are three kinds:

High-Voltage Power Supply—This power supply was designed to furnish plate voltage for one of the large Signal Corps mobile high-frequency sets. Manufactured according to Signal Corps specifications, it combines all of the usual features found in commercial equipment, plus additional safety factors in design necessary in equipment destined to operate under all types of field conditions. The output voltage obtainable from the unit is continuously variable from 0 to 15,000 at 500 ma when type 371-B rectifier tubes are employed. It is possible to substitute 872-A rectifier tubes in the unit without major circuit changes and obtain much higher output current at voltages up to 6,000 volts.

Triple Power Supply—This unit contains three power supplies employing a two-stage-amplifier voltage-regulator circuit which assures regulation and freedom from hum. Power supply No. 1 has a variable-voltage range from 750 to 900 volts dc at a maximum load of 125 ma. Line voltage may drop to as low as 85 v ac on medium loads and 100 v ac on maximum loads, throughout the voltage range from 750 v dc to 900 v dc. The ripple content within these voltage ranges is less than 5 millivolts from no load to full load.

Supplies number 2 and 3 are identical, having a variable voltage range from 230 v dc to 330 v dc at a maximum load of 400 mils. Line voltage may be as low as 80 volts at 200 ma and 100 volts at maximum load. Ripple content is less than 5 millivolts at all loads and voltages.

Low-Current Power Supply—This unit supplies voltages between 500 and 15,000 volts dc at 35 ma. Ripple voltage at full load is 6 percent.

Original Equipment Expensive

It is not possible at this time to estimate the number of units that will be available from obsolete high frequency equipment. There were about 2800 of one model manufactured and approximately 1000 of the other, at a cost of well over $200,000,000 to the government. How many have been destroyed and how many are listed as surplus is not known. It has been estimated that the average cost of one complete model is about $40,000. As a single unit this model would be a dead loss to the government.

There will be some surplus units which cannot economically be adapted to meet civilian needs. When this fact has been clearly established, normally after complete investigation by more than one manufacturer, the RFC will approve the salvage of components. For instance, there is one particular tube used in a set which represents a government investment of between four and five million dollars. Each tube, which originally cost about $50, now is priced at $19 and the only recoverable value seems to be about 30 cents for the platinum in it. So far, no verdict has been handed down regarding its disposal.

To date the following approximate numbers of tubes have been declared surplus by Owning Agencies at the dollar value indicated opposite each type:

Type	Quantity	Value
Receiving tubes	3,158,000	$1,900,000
Transmitting tubes	2,862,700	11,700,000
Cathode-ray tubes	136,000	1,860,000
Photoelectric tubes	12,800	10,500
Special-purpose tubes	54,300	78,500
Other tubes	106,000	447,000

Of the above tubes declared surplus, practically 100 percent have been returned to DSC manufacturer-agents, save for approximately 510,000 transmitting type tubes, valued at $5,560,000, and 13,000 cathode-ray tubes, valued at $195,000.

Anti-Trust Law Clause

An important clause in the Surplus Property Act, which cannot be overlooked in any discussion of surplus disposal, has to do with avoiding any violation of the anti-trust laws. It states in Sec. 20:

> "Whenever any disposal agency shall begin negotiation for the disposition to private interests of a plant or plants or other property which cost the Government $1,000,000, or of patents, processes, techniques or inventions, irrespective of cost, the disposal agency shall promptly notify the Attorney General of the proposed disposition and the probable terms or conditions thereof. Within a reasonable time, in no event to exceed ninety days after receiving such notification, the Attorney General shall advise the Board and the disposal agency whether, in his opinion, the proposed disposition will violate the antitrust laws. . . . Nothing in this Act shall impair, amend, or modify the antitrust laws or limit and prevent their application to persons who buy or otherwise acquire property under the provisions of this Act."

The Department of Justice has gone over the RFC agreement forms and to date has found no violation of the antitrust laws.

The agency agreement contains a provision that the manufacturer may not, without the prior consent of RFC, sell more than 80 percent of any type of equipment or component shipped to him, nor may he purchase more than 50 percent of any type for use in his own production unless the prior consent of RFC is given. This safeguard was set up to assure the government that government-owned surplus would not be used by any manufacturer to place himself in a preferred position at the expense of other manufacturers or the industry as a whole. These restrictions do not apply in the event of sale of the equipment or components for use in war production.

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Motor Noise Unit fo

By BYRON E. PHELPS
International Business Machines Corp.
New York, N. Y.

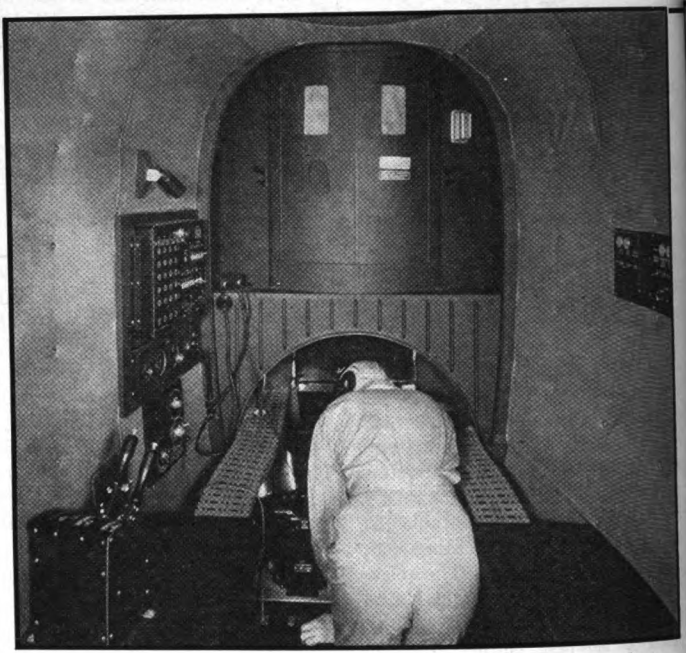

FIG. 1—Interior of the bombardier's compartment in the PB4Y mockup. Two loudspeakers are mounted behind the cloth wall above the bombardier's head and two others are concealed in dummy ammunition boxes at each side

THE 7-A-3 bombing trainer was developed by the Navy Bureau of Aeronautics, Special Devices Division, to give the student bombardier authentic bombing practice and experience without leaving the ground. The trainer reproduces every condition encountered in actual bombing procedure so accurately that the student needs little adjustment when he eventually goes aloft. It consists of a replica or mockup of the bomber compartment of a huge four-motored heavy bomber (PB4Y), known by the Army designation as the Consolidated B24.

All the instruments, including a late model bombsight, are included in the mockup. An ingenious projection device produces a moving image of the ground or target area in exact proportion to the speed and altitude of the plane. Refrigerating equipment is used to cool the compartment to make it necessary for the student to learn how to handle delicate instruments while encumbered with bulky flying clothing.

To complete the realism, it was necessary to duplicate the motor noise and vibration which would be present in a real plane. Such a motor-noise unit must duplicate as nearly as possible the actual motor sounds as heard in the bombing compartment. It was also desired that the speed of the "motors" be controllable by the instructor, and that at least two separate noise generators or motors be used so that the characteristic low-frequency beat of multiple motors not in exact synchronism could be obtained.

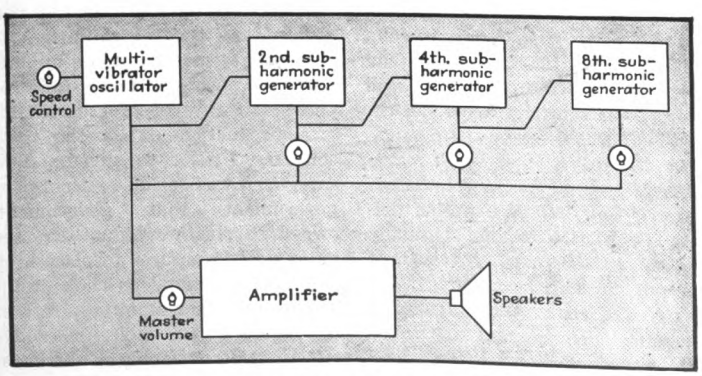

FIG. 2—Functions of the several stages of the noise generator are illustrated by this block diagram

Noise Analysis

The development of the motor-noise unit was based on a simple analysis of the noise produced by an airplane engine. It was assumed that most of the noise came from the exhaust and that the exhaust produced the fundamental noise frequency; also that the exhaust note varied from cylinder to cylinder due to variations in cylinder conditions and in length of exhaust piping and that this variation would occur rhythmically at a frequency several times lower than the fundamental, depending on the number of cylinders and the type of exhaust manifolding; also, there would probably be other variations or added sounds caused by propellers, bearings, timing gears, etc.

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for Aircraft Trainer

To simulate the motor noise and vibration present in an airplane, electronic units are used in bombing trainers. A multivibrator produces the fundamental tone, three trigger circuits add subharmonic frequencies, and the resultant tone is amplified

These again would have basic frequencies several times lower than that of the exhaust fundamental.

Based on this analysis, a device to simulate motor noise should have a fundamental tone generator whose output would resemble the exhaust, plus several tone generators or tone modifiers which would operate at frequencies lower than the fundamental to simulate the variations in, or additions to, the exhaust note. Rather than attempt to analyze just what frequencies should be used for these modifying tone generators, the problem was approached from the angle of how realistic a sound could be obtained by using modifying frequencies most easily obtained.

Multivibrator as Tone Source

For the fundamental exhaust note generator, a conventional twin-triode multivibrator oscillator was used. This type of oscillator was chosen for two reasons, first because the relatively square-wave output (with some modification) gave a very realistic sound output; and second, because the frequency of oscillation or speed could be varied over a wide range by means of a simple dual potentiometer.

To produce the modifying tones, a series of three trigger circuits were added as frequency dividers. These were connected in cascade and driven by the multivibrator so as to produce respectively a first, second, and third subharmonic frequency. (Since this was essentially a sound problem, the musical harmonic terminology was used. In the usual radio terms these would be the second, fourth and eighth subharmonics). When the subharmonics are properly blended with the output of the multivibrator and the resultant amplified and converted to sound by suitable speakers, the result is a very realistic imitation of an airplane engine.

Each trainer uses two noise units, each of 30 watts peak power, and each driving two twelve-inch heavy-duty speakers. The sound is not only quite intense but also produces considerable vibration in the mock compartment, which adds much to the impression of being in a real plane.

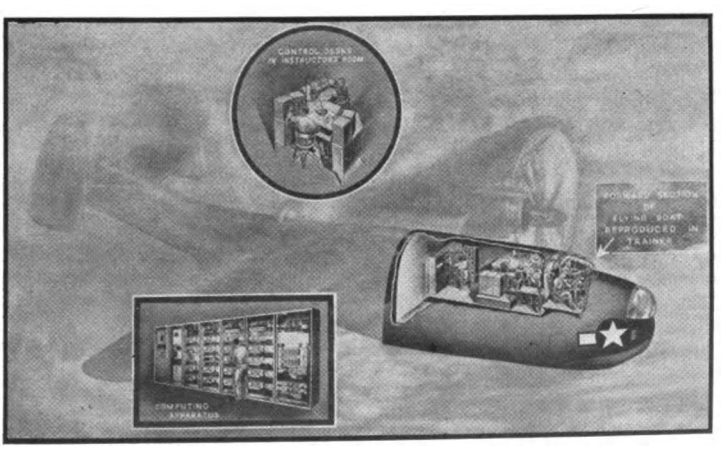
Figure 1 shows the interior of the mockup of the PB4Y bombing compartment. Figure 2 shows a block diagram of the noise generator. Other photos show the production models of the noise unit chassis which contains two separate noise generators complete with separate amplifiers and separate power supplies.

Signal Generation

The operation of the circuit shown in Fig. 3 is as follows:

The multivibrator oscillator is of the conventional twin-triode type employing a 6SN7 twin triode tube. The cathodes of the triode elements are connected to the +90-volt line and the plates to the +240-volt line through 40,000 ohms total plate load each. The grids are each returned to the cathode, +90-volt line, through an adjustable resistance of 100,000 ohms maximum and a limiting resistor of 5,000 ohms. The 100,000-ohm adjustable resistors are the two halves of a dual potentiometer.

Each triode plate is coupled to the grid of the opposite triode plate through a 0.1-μf capacitor. So connected, the twin triodes act like a see-saw, with first one tube conducting and then the other. To follow through the operation very briefly, assume that the triode section on the left starts to conduct. As it starts to conduct, its plate volage will drop nearly to cathode potential. This sudden shift downward in potential is transmitted to the right-hand grid through the 0.1-μf coupling capacitor, making the right hand triode non-conductive. The right-hand grid will immediately start to rise back to cathode potential as the charge



PBM3 flight crew trainer. It includes electronic equipment designed to simulate motor noise and similar to the gear discussed in the text

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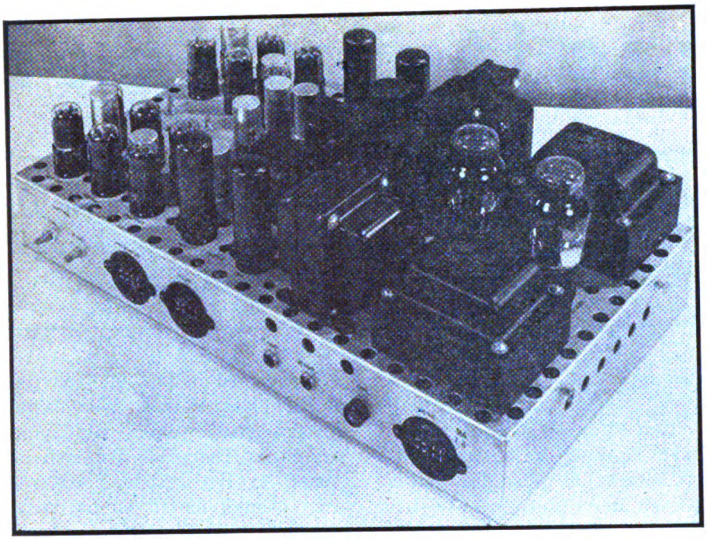
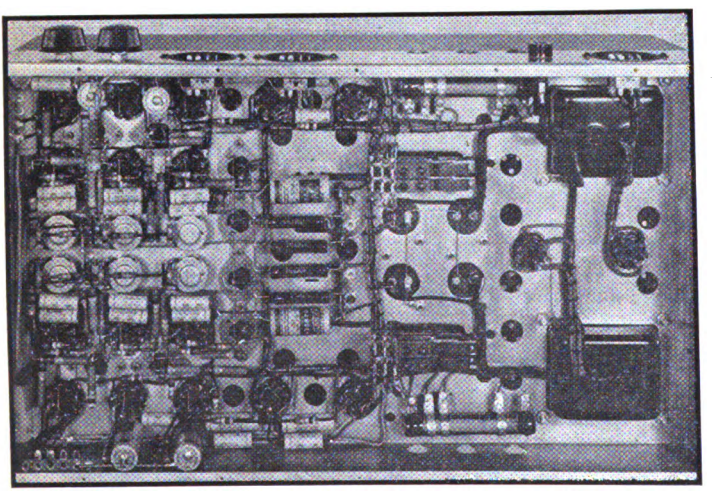


Two complete tone generators and amplifiers are mounted on one chassis. Separate power supplies are included for each



Under-chassis view of the electronic portion of the noise generator. Shielded leads permit the speed controls to be located on the instructor's desk

leaks off the coupling capacitor through the variable grid resistor. When a potential of 10 volts negative to cathode is reached, the right-hand triode will start to conduct and in a similar manner bias off the left-hand triode. When this newly created bias on the left-hand triode leaks off, it will again conduct and bias off the right-hand section.

The rate at which this transfer, see-saw, or oscillation occurs is determined by the discharge rate of the coupling capacitors through the grid-return resistors. By making the latter variable, it is possible to vary the frequency over a very wide range. In the circuit shown, the change from minimum resistance of 5,000 ohms to a maximum of 105,000 ohms produces a speed change of from 300 down to 20 cycles per second. For signal output, one plate resistor is tapped at the midpoint and coupled to the common amplifier input through a 1-megohm decoupling resistor. A direct plate connection is used to furnish the signal for driving the first subharmonic generator.

Trigger Circuit as Frequency Splitter

The first subharmonic generator consists of a trigger circuit of the Eccles-Jordan type, but with the component values so chosen that it responds only to negative pulses and can thus be used as a frequency divider without additional tubes. It consists of the two triode elements of a 6SN7 twin triode tube, with the plate of each triode coupled to the grid of the opposite triode in such a manner that if either triode is conducting it will hold the grid of the other triode well below cutoff. Thus either triode may conduct, but only one can conduct at a time.

A negative impulse applied simultaneously to both grids through the 0.00045-μf coupling capacitors will momentarily bias off the conducting triode and the other triode will become the conducting one. A second negative pulse will cause the first triode to again conduct, etc. Thus two negative pulses will produce one complete alternation, see-saw, or oscillation.

Within reasonable limits, a positive pulse will not effect this trigger. When the 0.00045-μf capacitors are coupled to the right-hand plate of the multivibrator, the trigger grids will receive one negative impulse for every cycle of the multivibrator and will make one complete alternation or cycle for every two cycles of the multivibrator. Thus whatever the multivibrator frequency, the 1st sub-harmonic generator will oscillate at one-half its frequency.

Mixing the Outputs

Likewise, the 2nd subharmonic generator, coupled to the output of the first subharmonic generator, will oscillate at one-half the frequency of the first subharmonic generator or one-quarter the frequency of the multivibrator. The third subharmonic generator will oscillate at one-eighth the multivibrator frequency.

The output of each subharmonic generator is controlled by a 0.5-megohm potentiometer and is coupled to the common amplifier input through a 1.0 megohm decoupling resistor. The best blending for normal use consists of all three potentiometers in approximate physical center although special effects can be produced by other proportions. For example, a pronounced knocking like that caused by a loose connecting rod can be produced at low speed by turning

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the third subharmonic control full on.

Power Amplifier Stages

The audio amplifier is of conventional design employing a 6J5 first audio amplifier, 6SN7 as second audio and phase inverter, and two 6L6's as power amplifiers. The only departure from standard design is in the coupling between the first and second amplifiers. A small 0.005-μf coupling capacitor is used with a 0.01-μf tone-control capacitor. This combination was selected from many possible combinations to provide the most realistic sound output as judged by experienced airmen. The sound output is designed to resemble that inside the bombardier's compartment rather than that heard from outside the plane.

Multivibrator oscillators as used in this device are very sensitive to voltage variations and tend to lock in with each other if any appreciable coupling exists. Any tendency to lock in would defeat the main purpose of the dual units, that is, to produce the characteristic low-frequency beat of multimotored planes with motors not in exact synchronism. Therefore the units were isolated physically and electrically as completely as possible.

Separate power supplies were used for the same reason, plus the fact that it permitted the use of two standard receiver type power transformers rather than one special heavy duty transformer. It was necessary also to shield the leads to the speed-control potentiometers which were mounted on the instructor's desk at some distance from the chassis.

Reproducer Problem

The loud speakers which produce the final sound output are mounted within the mock compartment and presented problems of their own. The frequencies to be reproduced were very low, normally ranging from 200 cycles for the fundamental oscillator frequency to 50 cycles for the third subharmonic, and lower if the speed was reduced. To make it worse, the mockup construction permitted very little baffle area. Almost no data was available to suit these conditions. Speaker manufacturers considered the conditions almost impossible for suitable results.

After considerable experimentation and testing, the loudspeakers were arranged as follows: Two 12-inch, heavy-duty pm units with peak ratings of 30 watts each were used for each amplifier (four per dual unit). To provide low-frequency loading, the speakers were mounted in independent, totally enclosed baffles with a volume of approximately one cubic foot, the shape of the baffle box being determined by its location in the trainer. Without the loading by these enclosed baffles the speakers would soon tear themselves to pieces.

Two of the speakers are mounted, concealed behind the cloth lining, above and on each side of the bombardier's head, and two are mounted in the dummy ammunition boxes below and to the right and left of the bombadier. The speakers on one side are connected to one amplifier to further the sense of separate motors. While far from ideal, this speaker arrangement has given satisfactory sound output and excellent speaker life.

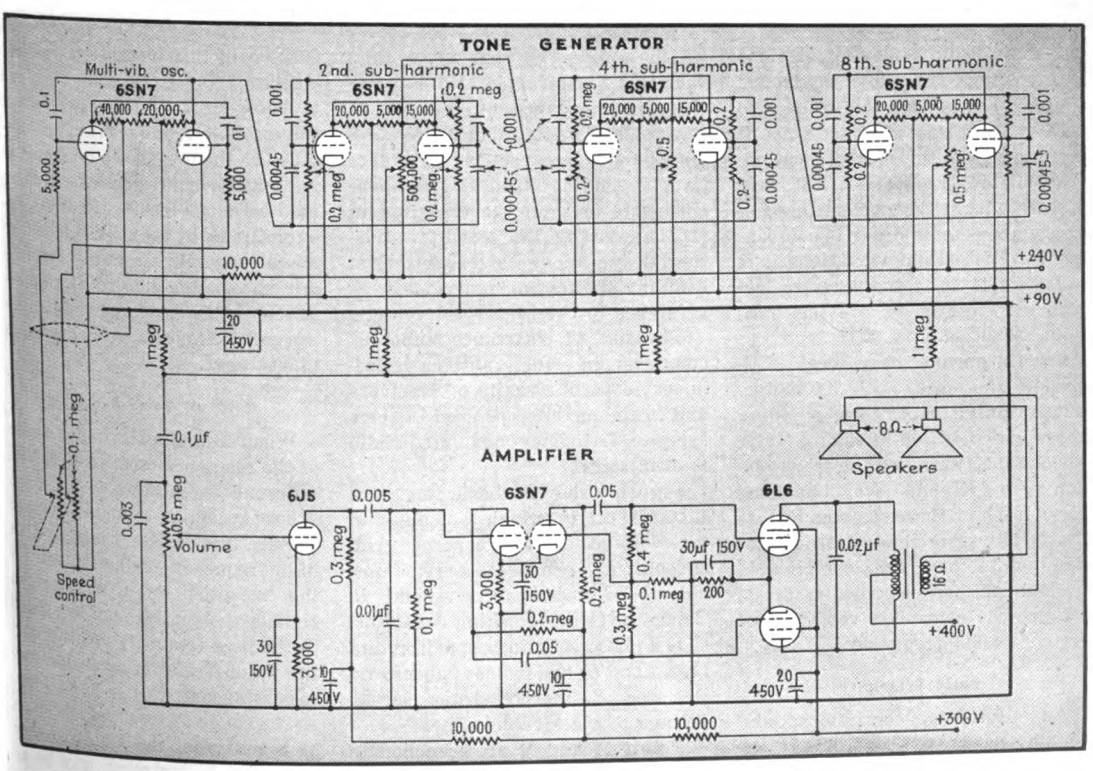

FIG. 3—Circuit diagram of the noise generating unit for simulating the engine exhaust sounds of a plane in flight

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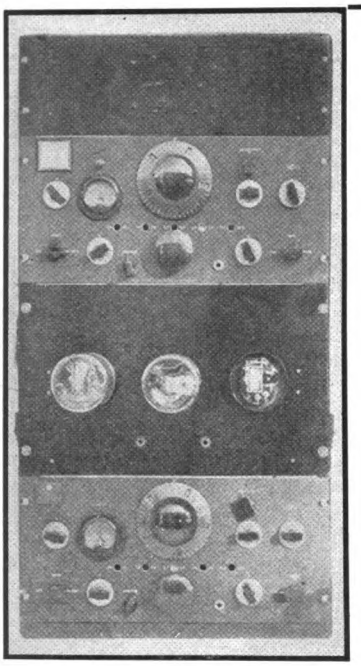
Remote Tuning

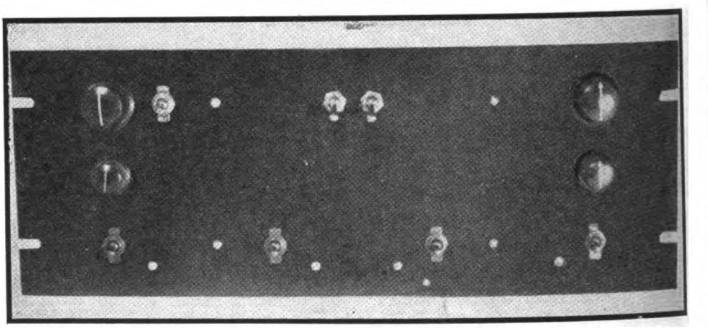


Remote-controlled unit, containing C-W and C-W–phone receivers, and relays

Remotely-located radio receivers are tuned over a limited band by means of reactance tubes connected across their oscillator tank circuits. The reactance tubes are controlled by direct voltages applied over connecting telephone lines

By H. B. BARD, Jr.

Radio Engineering Aide
U. S. Immigration Service
Los Angeles, Calif.



Office control unit, providing on-off control and tuning control of two remote receivers, and local volume control

IN MOST radio receiving stations involving remotely controlled equipment it is desirable to be able to exercise at least a limited amount of tuning from the control location. Transmitter frequencies will vary slightly within the permissible tolerance allowed. In order to compensate for such slight variations it is necessary to shift the receiver frequencies slightly to provide optimum reception.

Several means have been utilized in the past, such as motor-driven tuning capacitors, stepping relays which switch in various crystals or capacitors, and the transmission of i-f signals over telephone lines. Each of these systems has its merits but from the constructional standpoint they are complicated mechanically or electrically, or do not provide continous variation of the controlled frequency.

Basic Principle

An electronic, continuous, and simple means of control can be achieved by utilizing a reactance-tube circuit. Such a circuit is one in which a direct-current or voltage variation is converted into a variation in impedance at the output terminals. The impedance variation may be either capacitive or inductive, depending upon the component parts used in the circuit, and is achieved by the use of a tube that draws from its load either a leading or lagging current with reference to the impressed voltage.

The use of reactance tubes is common in the automatic-frequency-control circuits of receivers and in the modulators used in some types of frequency-modulated radio transmitters.

Figure 1 shows a basic reactance tube circuit in which a change in d-c voltage on the control grid, through R_1, produces a reactance change between points A and B. Capacitor C_1 is a blocking capacitor, C_2 is a phase splitting capacitor, and C_3, C_4, and C_5 are bypass capacitors. Resistor R_2 merely drops screen voltage to a desirable value.

Points A and B are attached to the circuit over which control is desired. In the example under discussion in this instance, a receiver oscillator is to be controlled and therefore AB is connected across the oscillator tank circuit. Inasmuch as the impedance presented at AB may have a resistive term, there will be some loading of the oscillator circuit by the control tube. The magnitude of the resistive term diminishes as the phase difference between the grid voltage and the impressed voltage at AB approaches ninety degrees.

C-W vs. Voice Reception

When tuning a receiver by means of the reactance-tube circuit several different methods may be used. Where reception is limited to voice signals, it is necessary to control the high-frequency oscillator, but for the reception of C-W telegraph signals the control may be applied to the beat-frequency oscillator and the high-frequency oscillator may be crystal controlled.

The range of frequency variation at 5 mc when the high-frequency oscillator is controlled may be as high as 30 kc with a 12-volt bias

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With Reactance Tubes

variation. When the control is applied to the beat-frequency oscillator at 465 kc the available variation in beat note is approximately 10 kc each side of zero beat for a total bias variation of 12 volts. The amount of variation, or control, is largely determined by the amount that the grid bias on the reactance tube is varied and the value of the coupling capacitor C_1; the larger this capacitor the greater the control.

Circuit Variation

Figure 2 shows schematically a typical installation in which two receivers are remotely controlled over two telephone lines. Closing the dpst power switch at the office turns on the office amplifier and also turns on the remote receivers. Closing the tuning switch at the office applies bias to the two remotely located reactance tubes. Variation of the tuning-control potentiometers changes the output reactance of the two reactance tubes and accomplishes the desired tuning. Audio output of the two receivers is fed back to the office over the associated telephone lines and applied to the office amplifier input through potentiometers and spst switches providing individual control.

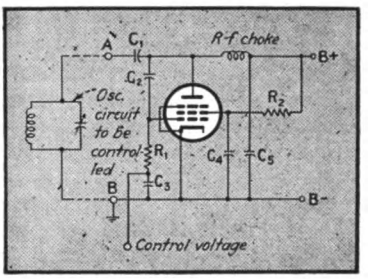

FIG. 1—Fundamental reactance-tube tuning circuit

In this instance one remote receiver is used for c-w reception and the other for voice and therefore one reactance tube controls a beat-frequency oscillator while the other controls a high-frequency oscillator, as previously outlined. Where both c-w and voice are to be received with one receiver it is a simple matter to arrange remote switching of a reactance tube from beat-frequency oscillator to high-frequency oscillator or vice versa. In such instances additional relays are connected in series with the power relay and adjusted to pull up at different currents. An additional potentiometer included in the relay battery circuit permits suitable currents to be selected.

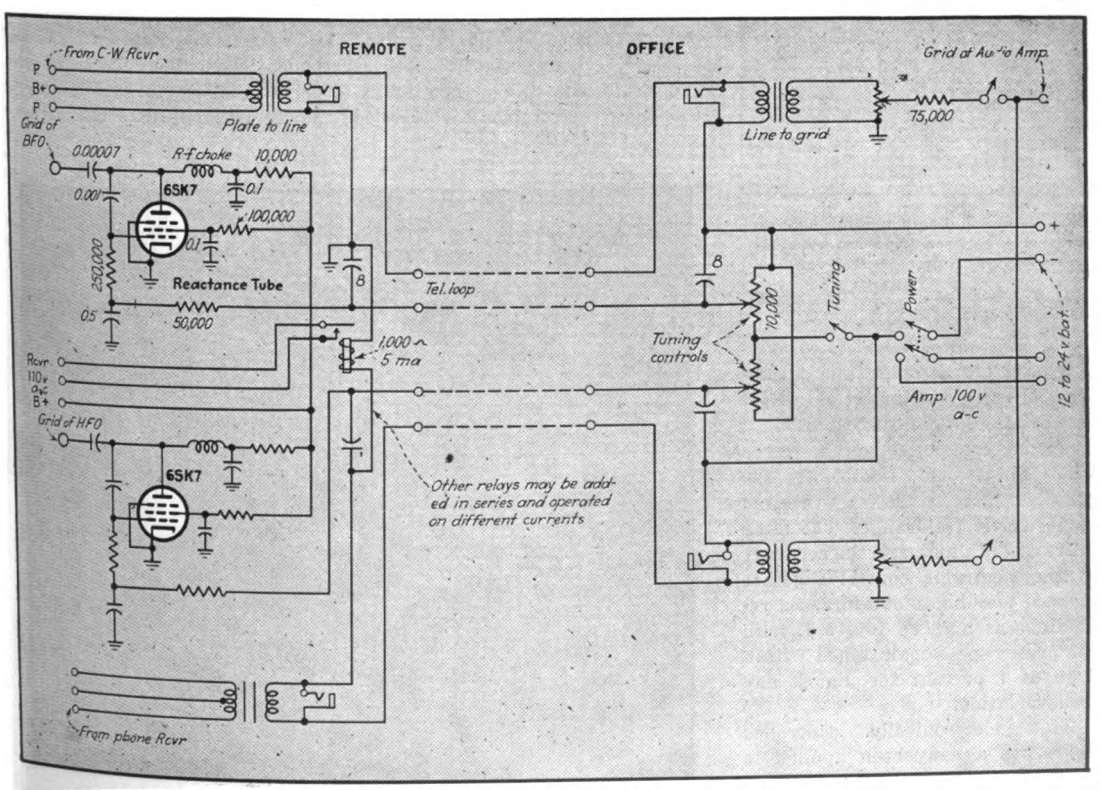

FIG. 2—Remote-tuning arrangement suitable for handling two receivers. Addition of other relays and another potentiometer permits a number of variations discussed in the text

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Electronic Control for

By exciting a magnetic clutch with a grid-controlled gaseous rectifier that is controlled by a governor generator through a bridge circuit having a vacuum tube in one leg, the output speed of a motor can be varied over a 100-to-1 range or a preset speed automatically maintained within 0.1 percent from no load to full load

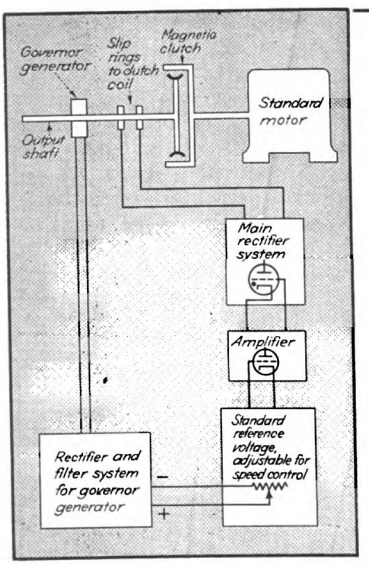


FIG. 1—Block diagram illustrating relationship between important elements of an electronically controlled variable-speed drive

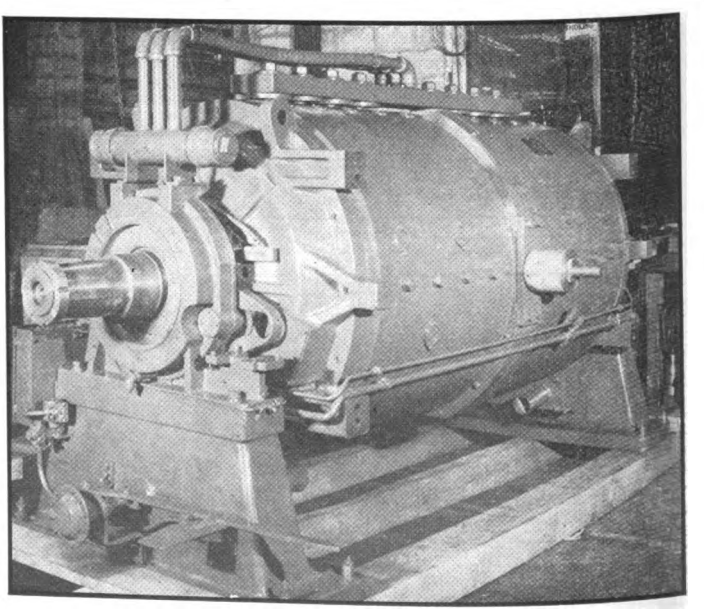
AN electronically controlled magnetic clutch operating in conjunction with a standard a-c motor has proved highly successful as a means of controlling speed over a wide range and regulating the speed accurately at any desired value within this range. The flexibility of the clutch and the accuracy of the electronic control together make it possible to obtain speed reductions as high as 100 to 1, with the preset speed maintained within 1/10 of 1 percent for almost any load variation.

This electronically controlled drive has already been applied in connection with wind tunnels, dynamometers and superchargers in sizes from ¼ hp up to 18,000 hp and speeds of from 100 to 30,000 rpm. Machine tool manufacturers have also used this combination successfully when extreme speed ranges are required.

One motor car manufacturer, who is now making aircraft engines, uses the magnetic clutch for testing these engines. One end of the clutch is coupled to the aircraft engine, while the other end is connected to a synchronous alternator. The engine may run at any speed while the alternator runs at a fixed speed. The difference in speed is taken up in the clutch. The d-c excitation to the clutch is controlled by an electronic rectifier system. In this manner, the major portion of the energy supplied by the aircraft engine is recovered, the remainder being dissipated as heat. When testing at speeds below that of the alternator, the alternator is stopped through the use of a friction brake, and the energy developed by the engine is entirely dissipated in the clutch.

Essential Elements of Electronic Drive

A functional diagram of the component elements of a variable-speed drive is shown in Fig. 1. Driving power is supplied to the magnetic



A 4,000-hp dynamometer whose power absorption is readily controlled by means of electronic speed-control equipment

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Magnetic Clutches

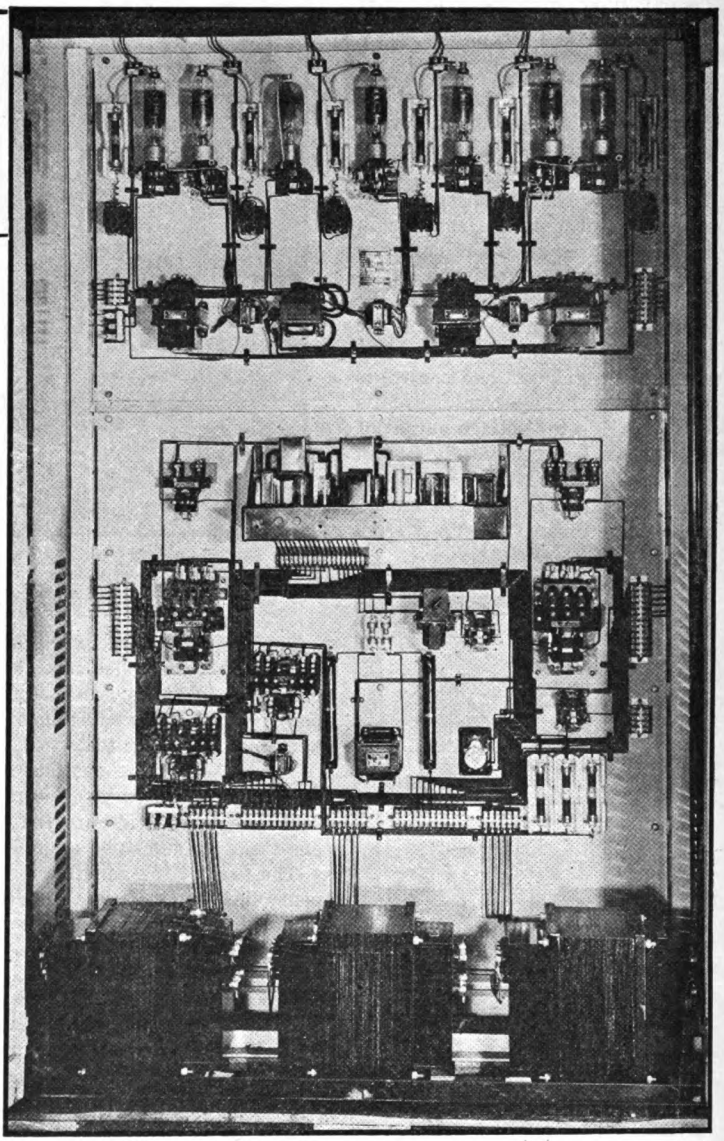
By RALPH L. JAESCHKE
Dynamatic Corporation
Kenosha, Wisconsin

clutch by a standard motor. The output shaft of the clutch operates at some desired fraction of rotational speed, determined by the governor generator that feeds the electronic control system which provides excitation for the clutch. The success of the control mechanism depends upon (1) the production by the governor generator of a voltage that is exactly proportional to the speed of rotation of the output shaft, (2) an electronic control circuit that may be manually operated to adjust the speed to any desired value but which is entirely automatic and precise in operation for any given setting of the speed control, and (3) an electrically operated clutch mechanism responding to the resultant voltages from the manual speed control and the voltage from the governor generator. Each of these three units will be described separately.

Characteristics of Governor Generator

A small a-c governor generator of the permanent-magnet type is placed on the output shaft of the clutch, as indicated in the block diagram of Fig. 1. The voltage of this generator is a linear function of rotational speed, as shown in Fig. 2, as is also the frequency of the a-c output.

The electronic control system requires for its proper functioning a direct voltage whose magnitude is proportional to the rotational speed of the output shaft. Accordingly, the output of the governor generator is fed into a full-wave rectifier with suitable filter. A d-c generator could be used in place of the a-c generator, thereby eliminating the rectifier and filter system, but considerable trouble with commutation, brush wear, electrical leaks to ground, and maintenance problems in this case makes the a-c governor more economical and desirable.



Rear view of control designed for providing 15-kw d-c excitation for 4,000-hp dynamometer

In practice the lowest frequency of the generator is 60 cps and the highest is about 4,000 cps except in cases where the clutch is operated at speeds as high as 30,000 rpm, when the maximum frequency is then approximately 15,000 cps. Rectification and filter problems are at a minimum at the higher frequen-

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cies, thereby making it possible to obtain smoother operation with a small, low-cost filter system. Filters in a high-frequency circuit may cause erratic operation and hunting due to the time lag required to charge the capacitors.

Electronic Control Scheme

Voltage output from the rectifier-filter system fed by the governor generator is thus proportional to the output speed of the machine. Slight variations or changes in speed will result in proportionate changes in the output voltage of the governor generator system, and such variations may be used to regulate the clutch mechanism to control the speed of the output shaft. The necessary regulation and control is effected in the electronic circuits by comparing the voltage output of the governor generator system with a standard reference voltage which may be adjusted manually to give the desired speed.

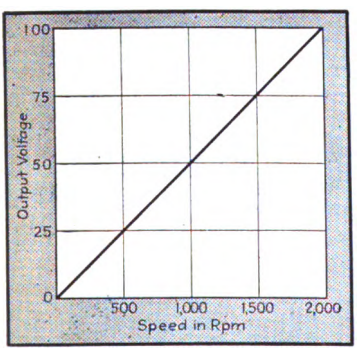

FIG. 2—Curve showing relations between speed of rotation and output voltage for typical governor generator

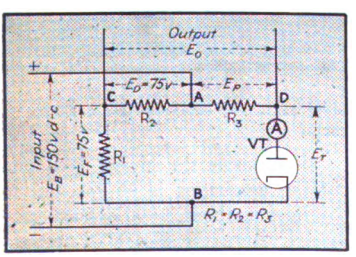

FIG. 3—Vacuum-tube bridge circuit which functions as control element for actuating the thyratrons feeding the magnetic clutch

Rear view of chassis using circuit of Fig. 4. This control unit supplies 220 watts of d-c excitation for machines of from 1 to 75 horsepower

The electronic control circuit is essentially a controlled rectifier using gaseous tubes, whose output power varies the excitation to the windings of the clutch.

The plates of the gaseous rectifiers are operated from an a-c source and the grids are fed by a one-stage vacuum-tube amplifier.

The grid of the amplifier tube is controlled by two variable electrical devices. One is known as the reference voltage, and is provided by a potentiometer connected across a d-c voltage source. This is usually termed a speed-setting control, since any predetermined setting of this control will cause the machine to run at a specified speed. The second voltage is obtained from the rectifier-filter system associated with the governor generator. These two voltages are connected in series opposition, and are of such magnitude that the signal voltage to the grid of the amplifier tube is zero when the output shaft is rotating at the desired speed. The signal voltage will be positive when the output shaft rotates faster than the desired speed, and will be negative for speeds slower than the selected value.

Reference Voltage

The reference voltage is obtained from a transformer-rectifier-filter system operated from the line. Voltage stability is obtained through the use of voltage regulator tubes of the VR-150 or VR-105 type, although in cases where extreme constancy of voltage is required, an elaborate voltage regulator system is employed. The closer the reference voltage is held to a predetermined value, the better will be the speed control of the machine. The output of the voltage-regulating system is brought to a manually operated voltage divider which provides a convenient means for adjusting the machine to its required speed.

The sum of the two voltages, reference and governing, is then brought to the grid of a triode amplifier tube arranged as a driver for the final output tubes. This amplifier tube is in a balancing bridge circuit, similar to a Wheatstone bridge circuit, and is shown

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in Fig. 3. The tube forms one arm of the bridge.

Complete Circuit

Resistances R_1, R_2, and R_3 are of equal value. Therefore, when the cathode-plate resistance of the triode is equal to R_1, the bridge is balanced and the output voltage E_o is zero. When the triode does not pass current, no voltage drop will exist across R_3. In this case a voltage drop, equal to one half that applied across AB, will exist across R_2. Point C will then be more negative than A by the voltage drop across R_2. This voltage drop will appear as $E_D = E_o$ since $E_P = 0$ now, and will be applied to the grid of the gaseous controlled rectifier.

Should the signal on the grid of amplifier tube VT be positive, a voltage drop E_T, whose magnitude depends upon the plate impedance of the tube as well as upon the grid voltage of VT, will appear as the result of current passing through the tube. This will cause a voltage drop across R_3 which will be greater than that across R_2. Point D will be more negative than points A and C. Since the voltages developed across R_2 and R_3 are in opposition, the difference E_o will have a polarity opposite to that obtained in the previous case. This will cause the grid of the controlled rectifier to become negative, causing the current developed in its load to drop to zero. For instance, if the tube drop E_T is 10 volts, then E_P is 140 volts and E_o is $E_D + E_P = 140 - 75 = 65$ volts since polarity is in opposition.

In the more complete electronic speed-control circuit diagram of Fig. 4, this bridge is represented by tube VT_7 and resistors R_{12}, R_{13}, and R_{20}. The voltage E_B supplying the bridge is obtained from a transformer-rectifier-filter power supply employing a 5U4 full-wave rectifier tube. The output of the bridge circuit, E_o, is applied between the grid and cathode of gaseous controlled rectifier VT_2.

The half-wave grid-controlled gaseous rectifier VT_2 is connected across the clutch-coil load along with an uncontrolled gaseous rectifier, VT_1. Since the load is highly inductive, it is necessary to keep the high inverse voltages to a minimum in order to protect the insulation of the clutch coil and eliminate the destructive effects on the grid-controlled tube.

The gas type of grid-controlled tube was used because of its many advantages over the mercury type. Its cost is somewhat lower; it is not as large since it does not have to have a cold spot for condensation and, most important of all, its grid characteristics do not change with temperature as in the case of the mercury tube.

Should the machine be set to run at 1000 rpm by speed control voltage divider R_{17}, the reference voltage developed by VT_3 and regulated by VT_4 and VT_5 will be equal to the voltage developed by full-wave rectifier VT_6 when fed by the governor generator running at 1000 rpm.

With the output shaft of the clutch at rest but the driving member rotating, no voltage will be generated by the governor generator. As soon as speed control R_{17} is moved above zero speed, it will cause the grid of VT_7 to become more negative, allowing final output rectifier tube VT_2 to become positive and pass current through the clutch. This will start the pilot

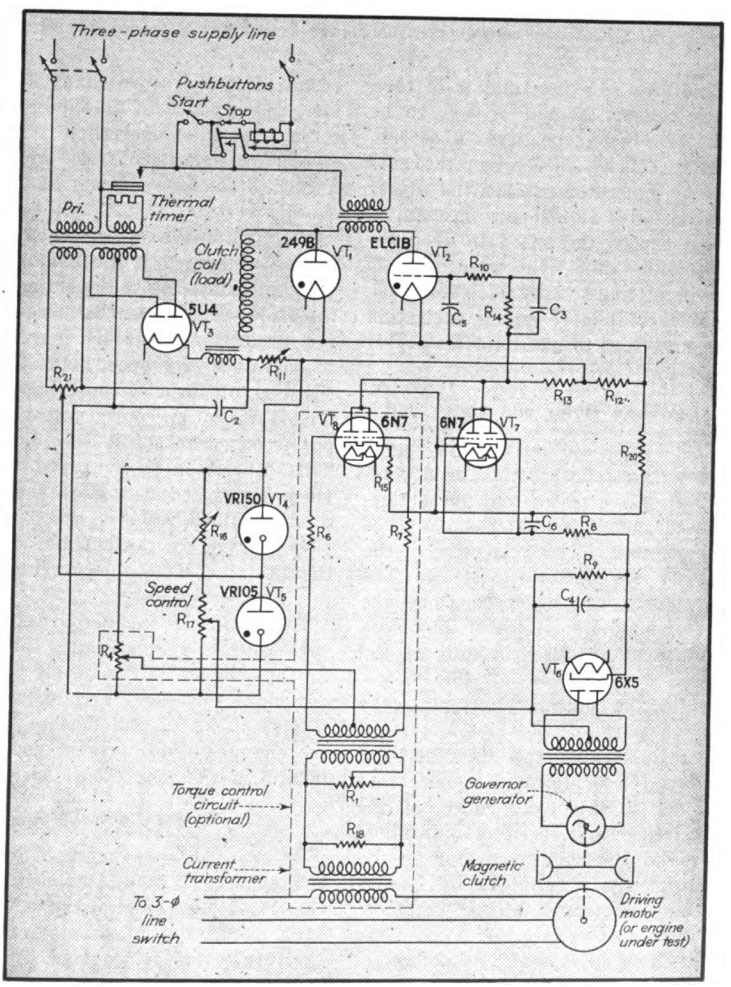

FIG. 4—Schematic wiring diagram of complete variable-speed drive unit. Tube VT_7 and its associated circuits form the bridge circuit illustrated in Fig. 3. The portion enclosed in dotted lines is the optional torque control circuit

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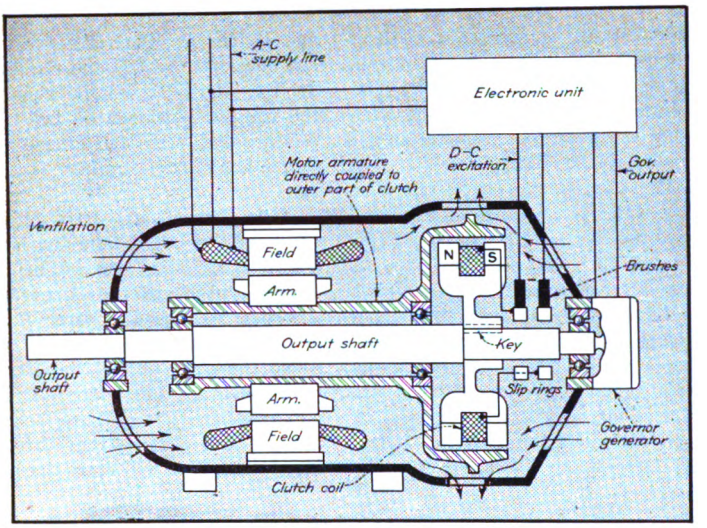

FIG. 5—Cross-sectional diagram illustrating construction of magnetic clutch

generator rotating, and it in turn will cause the grid of VT_1 to be driven in a positive direction. Balance is reached when the governor generator reaches the preset speed. If additional mechanical load causes the speed to drop below this value, the grid of VT_1 swings more negative and VT_2 passes still more clutch excitation in an effort to maintain its preset speed.

Combined Motor and Clutch Unit

The cross-section view in Fig. 5 shows the construction of a combination a-c motor and adjustable-speed magnetic clutch built as a single unit. The field poles of the motor are fixed in position. The armature of the motor and the outer magnetic circuit of the clutch rotate as an integral unit at the fixed rated speed of the motor, while the output shaft and the inner part of the clutch (carrying the clutch coil and the slip rings for bringing d-c energizing power to this coil) rotate at the desired output speed as maintained by the governor generator on the output shaft and the clutch-energizing electronic unit.

The output speed of a magnetic clutch-motor system is usually a function of d-c excitation current and load. At a fixed load and excitation, the speed output would remain fixed, the deviations being the result of temperature changes and air gap clearance in the clutch. In some cases, fixed excitation is sufficient for speed control, due to natural characteristics of the clutch.

To maintain a speed when the torque is changed, it is necessary to vary the excitation to the clutch. If the torque requirement is increased, the excitation must be increased to maintain the speed; therefore the use of an electronically controlled excitation source whose output is based on speed is desirable. This control is so arranged that, when the speed decreases from a predetermined setting, the excitation current increases; or, when the speed increases, the current output decreases.

A change in the clutch excitation causes a practically instantaneous change in the torque being developed. The accompanying change in speed will depend upon the change in torque and also the inertia of the connected load.

Torque Control

In many cases, the rate of acceleration must be limited, or in the case of loads which have a very high moment of inertia, a torque-limiting system is required. Torque control may be adapted to any excitation unit applied to a clutch used in conjunction with an a-c motor. This is done through the use of an additional circuit, shown inclosed in dotted lines in Fig. 4. Voltage obtained from a current transformer inserted in one motor lead is transmitted to amplifier tube VT_3 which is arranged to limit the quantity of d-c excitation to the clutch when a predetermined voltage, determined by the setting of R_4, is reached.

The torque control circuit will take over when a sudden speed change is made by the speed-setting control provided the horsepower output limitations of the motor are exceeded, thereby effecting gradual acceleration. In order to make the torque limit adjustable, a small voltage divider R_1 is placed in the current transformer circuit so that the machine setting may be easily adjusted.

Anti-Hunt Circuits

The success of such an electrical-mechanical system depends upon the anti-hunt circuit used. A capacitor-resistor combination R_3 and C_3, whose time constant must be equal to the time constant of the machine, is used for this purpose. To operate such a system without an anti-hunt circuit, it is necessary to make the system very broad or inefficient with the result that the fine speed control characteristics are lost.

Applications

The same speed control may be applied to dynamometers, the only difference being that the function is reversed. Instead of driving some device, the dynamometer is driven. Should the speed tend to increase over a preset limit, the excitation current would increase, causing more horsepower to be absorbed in the dynamometer, and the torque would be shown on a suitable scale.

Electronic variable speed control mechanisms are available as standard equipment for motors of from 1 to 75 hp rating. A cabinet-mounted d-c exciting unit has also been designed to control the speed of a 4000-hp dynamometer. The same electronic control system may be successfully applied to rotating equipment covering an unusually wide range of power ratings.

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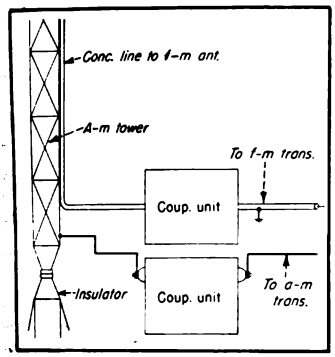


FIG. 1—To avoid short-circuiting the base-insulated a-m tower and to prevent a-m power from feeding back into the f-m transmitter an f-m coupling unit is used. In this instance it is mounted adjacent to an a-m coupling unit at the base of the tower

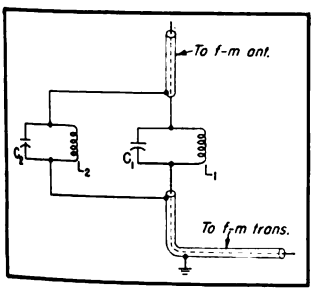


FIG. 2—Breaking the concentric f-m antenna feeder and inserting circuits resonant at the a-m frequency provides isolation at the a-m frequency

F-M Antenna Coupler

An f-m antenna at the top of a base-insulated tower used as an a-m radiator is fed through a concentric line without short-circuiting the tower. The coupling unit which accomplishes this is described in detail

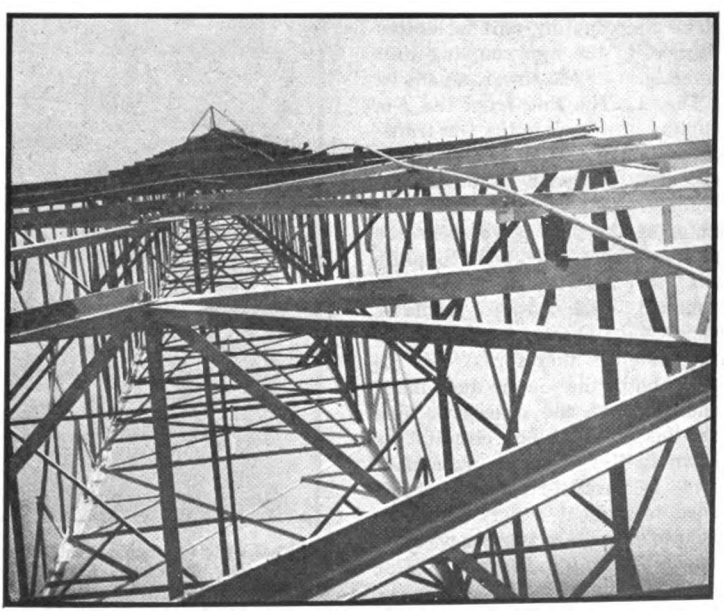
By JOHN P. TAYLOR

RCA Victor Div.
Radio Corp. of America
Camden, N. J.

WHEN an f-m antenna is mounted on a tower which is used as an a-m antenna it is necessary to provide an f-m coupling unit at the base of the tower. If the tower is of the insulated type, this coupling unit has two functions. The first of these functions is to pass the f-m feed line around the tower insulator without short-circuiting the latter at the a-m frequency. The second function of the coupling unit is to prevent r-f energy at the a-m frequency from passing back down the f-m feed line into the f-m transmitter and causing crosstalk at the f-m frequency. If the a-m tower is of the grounded type only the latter function is involved.

Various circuits suitable for use in f-m coupling units have been proposed. In a particular case, the circuit used depends largely upon the size and availability of the required components. This, in turn, depends chiefly upon the voltage across the tower insulator at the a-m frequency. Thus it is not possible to design an f-m coupling unit which will satisfactorily meet the requirements of all installations, any more than it would be possible to develop a universal a-m coupling unit. However, the fundamental problem is the same in all cases, and some useful ideas on the best method of solving it can be obtained by studying typical installations. One of these, the f-m coupling unit at WBRL, Baton Rouge, will be described here.

The f-m antenna of WBRL[1] is



The concentric line feeding WBRL's square-loop f-m antenna at the top of WJBO's a-m tower is purposely left loose to allow for expansion and contraction. The line may be seen running up from the right

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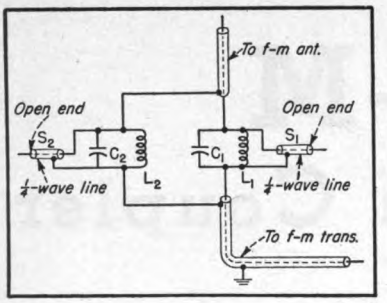

FIG. 3—Open-ended concentric lines S_1 and S_2 provide a low-impedance path for the f-m power

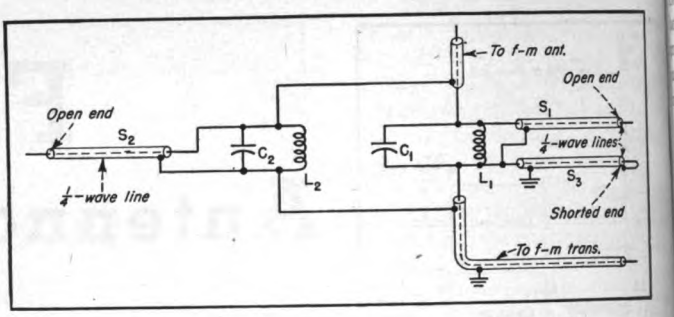

FIG. 4—In the final f-m coupler circuit quarter wave length line S_3 is added in order to effectively ground the lower end of circuit C_1L_1 with respect to a-m power. This line is shorted at its far end

mounted on the top of a 500-ft insulated, self-supporting tower which is the central tower of the three-tower directive antenna array of a-m station WJBO. The latter operates at 5 kw on a frequency of 1180 kc. At this frequency the tower is approximately a half wavelength high. Thus for daytime operation (non-directive) when power is fed to this one tower only, the base impedance is quite high. The f-m coupling unit must operate satisfactorily for this condition, as well as for the condition of nighttime operation (directional) when all three towers are used.

The Coupling Problem

The f-m coupling unit is located adjacent to the a-m coupling unit at the base of the tower, as shown in Fig. 1. The line from the f-m coupling unit back to the f-m transmitter in the station building is a concentric line with its outer conductor grounded. If the outer conductor of the part of the f-m line running from the f-m coupling unit to the tower were also grounded, the tower insulator would be short-circuited. The first step, therefore, is to break both the outer and inner conductors of the concentric line and insert blocking circuits as shown in Fig. 2. Here, L_1 and C_1 form a parallel-resonant circuit tuned to present a very high impedance at the a-m frequency. Components L_2 and C_2 perform a similar function.

At the f-m frequency, the blocking circuits have a lower but not entirely negligible value of impedance which it is desirable to bypass. To do this, concentric lines S_1 and S_2 are connected across these circuits as shown in Fig. 3. These open-ended lines present extremely low-impedances at their near ends when tuned to ¼-wavelength at the f-m frequency and therefore, provide the required bypassing. Insofar as the a-m frequency is concerned, lines S_1 and S_2 simply represent small capacitances in parallel with C_1 and C_2 and can be lumped in with these in the tuning operation.

Only one more element is needed to complete the f-m coupling arrangement, namely, the addition of a grounding line S_3, as shown in Fig. 4. This is a quarter-wavelength of concentric line shorted at the far end. Such a line presents an infinite impedance at the near end. Thus, when the outer conductor of line S_3 is grounded and the inner conductor connected to the bottom of L_1C_1 there is no short-circuit with respect to f-m transmission. At the a-m frequency, however, this length of concentric line is rela-

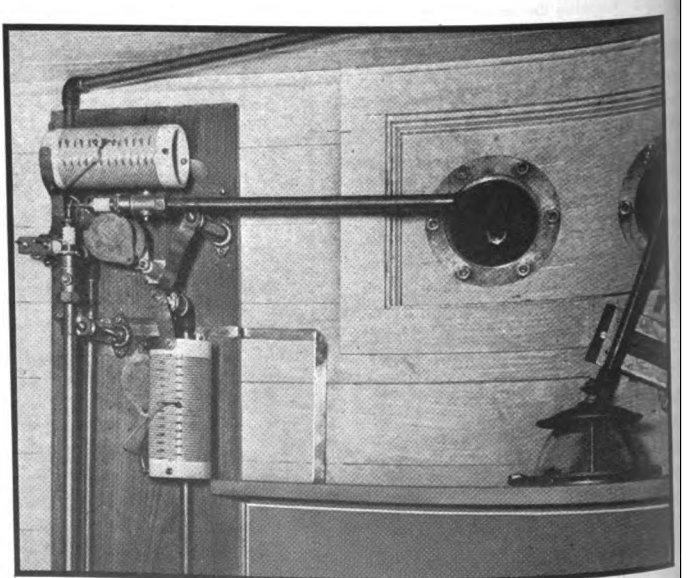

FIG. 5—The f-m coupling unit, mounted on a baseboard inside a doghouse at the bottom of the tower. The concentric line from the f-m transmitter comes in diagonally at the top. The concentric line from the coupler to the f-m antenna goes out through a bowl-insulator. Lines S_1, S_2 and S_3 drop down from the tuned circuits at the left. The a-m coupler is within the steel cabinet, the top of which is visible in the foreground, and the a-m feeder may be seen passing out through a bowl-insulator at the extreme right

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ively very short and, therefore, the bottom of L_1C_1 is effectively grounded at a-m frequency. This makes the blocking action of the circuit L_1C_1 much more effective.

Construction of the Coupling Unit

The components of the f-m coupling circuit are grouped on a baseboard which is approximately 1½-ft wide and 6-ft long. This assembly is mounted on the wall inside a doghouse adjacent to the a-m coupling unit, as shown in Fig. 5.

The ⅞-inch concentric line from the f-m transmitter, which is located in the transmitter house some 300 ft away crosses the ceiling of the doghouse at an angle and enters the f-m coupling unit at the top. The ⅞-inch concentric line to the f-m antenna leaves the unit on the right side near the top and passes out of the doghouse through a glass bowl insulator. This insulator is the same type as that through which passes the ⅞-inch copper pipe that forms the a-m antenna feed line.

Outside, f-m and a-m lines run side by side to the lowest brace of the tower, as shown in Fig. 6 and Fig. 7. At the tower, the pipe which forms the a-m line is solidly attached, while the f-m line continues on up the side of the tower.

Capacitors C_1 and C_2 are Type 77 Faradons. Inductances L_1 and L_2 consist of 53 turns of No. 12 solid wire, tapped every second turn. The three quarter-wave lines extend down along the baseboard. Since the outer conductors of two of these (S_2 and S_3) are grounded anyway, these two are mounted directly on the board. The third (S_1) is above ground, hence is mounted on insulators.

Tuning Procedure

Tuning of the coupling circuits is a two-step process, since adjustments must be found that permit the network to operate as required at both the a-m and f-m frequencies. Since the length of the lines S_1 and S_2 affects the a-m tuning as well as the f-m tuning, whereas the settings of L_1C_1 and L_2C_2 affect the a-m tuning only, it is necessary to make the f-m adjustment first.

The procedure in tuning for the f-m frequency is as follows: A 10-watt crystal-controlled r-f generator operating at the f-m frequency is connected to the input of the network where the line from the f-m transmitter normally connects. A 70-ohm load in series with an r-f milliameter is connected to the output of the network, where the line to the antenna is normally connected. The lengths of the lines S_1 and S_2 are then varied until placing a direct short across the near end of either of these lines produces no change in the output-meter reading. The length of line S_3 is next varied until connecting or disconnecting this line from the network has no effect on the meter reading. In other words, all three lines are adjusted so that they act like quarter-wave lines electrically even though they are physically somewhat shorter than a quarter-wave due to end effects and the lumped capacitance of the end seals. With the adjustments thus made, the f-m energy passes through the coupling network without power loss and without causing reflections on the line.

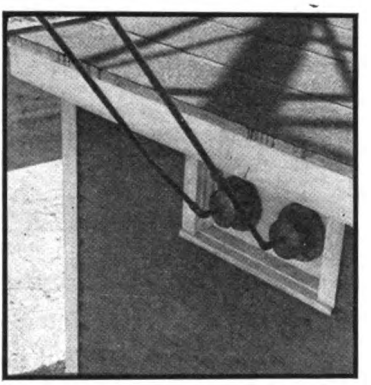

FIG. 6—Seen from outside the doghouse: Concentric f-m line at the right and a-m feeder at the left. Tower lighting lines are carried up inside the a-m feeder

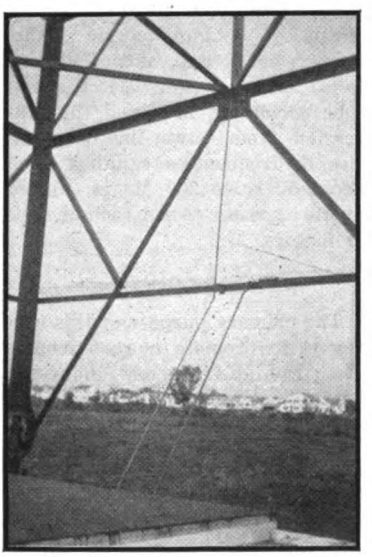

FIG. 7—The a-m line, at the right, terminates at the first tower-brace. A copper bond runs around the tower at this point. The f-m line continues up the tower

The procedure in tuning for the a-m frequency is as follows: First, the two parallel circuits L_1C_1 and L_2C_2 are adjusted approximately to resonance at the a-m frequency, using a low power oscillator as a driving source. Second, the network is disconnected from the concentric-line section feeding the antenna. The a-m transmitter is turned on, the a-m coupling circuit tuned and the a-m antenna current noted. Third, the outer conductor of the concentric line section running up the tower is reconnected and the change in the a-m antenna-meter reading noted. By slight readjustment of the tap on L_3, a point is found at which making and breaking the connection to the outer conductor of the line has no effect on the reading of the a-m antenna meter. Fourth, the inner conductor of the concentric line running up the tower is reconnected to the network and L_1 is adjusted until connecting and reconnecting has no effect on the a-m meter reading. When this is achieved the f-m line has no effect on a-m operations.

As a final check on the operation of the WBRL coupling unit, two types of field tests were made. The field intensity of the a-m station, WJBO, was carefully measured, using an RCA 308-A Field Intensity Meter, at several points—both with and without the f-m network connected to the tower. No difference could be noted. Also, extended observations of both the a-m and f-m signals were made, with high modulation and low modulation levels, using a high-quality receiver. No trace of cross-talk or cross-modulation was noted.

References

(1) Taylor, John P., A Square-Loop F-M Antenna. ELECTRONICS, 18, p. 96–100, March, 1945.

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Induction and Dielectric HEATING EQUIPMENT

Tabular comparison of technical characteristics and initial cost per kilowatt of output power for commercially available induction and dielectric heating equipment, as reported to ELECTRONICS by manufacturers. Both electronic and non-electronic types are covered

PRIOR TO THE ENTRY of the United States into World War II, practically all high-frequency heating was accomplished with experimental or custom-built units. However, the requirements of war production and the greater general acceptance of electronic devices opened new market possibilities until now there is available a wide-range of high-frequency heating equipment in standard commercial models. In addition, custom-built and special units are available from nearly all of the standard commercial-model manufacturers to meet special requirements.

Applications for high-frequency heating divide into two distinct groups: (1) induction heating units for melting, hardening, brazing, soldering, and heat treatment of metallic and conducting materials, and (2) dielectric heating units for heating, dehydrating, sterilization, or cooking of non-conducting materials such as tobacco, wood products, food, agricultural products, cereals, and the like. In some cases a given high-frequency heating unit may be used for either dielectric or induction heating. However, it is more general practice to designate a unit as a dielectric heating unit or an induction heating unit since the frequency range, circuit design, and power output electrodes differ rather widely in the two types of applications.

Four different types of equipment are in common use: (1) rotating machines, producing frequencies up to about 10,000 cycles per second and suitable only for induction heating, (2) mercury-arc frequency converters by which power at ordinary power line frequencies is converted into frequencies in the range of 1,000 to 3,000 cps, (3) spark-gap equipment in which a-c power is converted into oscillations at frequencies that can range from about 10 to 500 kc, by means of a high-voltage transformer, spark gap, and oscillatory tuned circuits, and (4) vacuum-tube oscillators in which the conversion from power-line frequencies to frequencies ranging from about 50 kc to 200 Mc is effected by air or water-cooled vacuum-tube oscillators.

Performance Comparisons

The primary purpose of this survey is to promote more extensive use of high-frequency industrial heating equipment by providing (so far as possible) a listing of the more important technical characteristics of various types of available commercial equipment (Table I). Unfortunately, available technical data on commercial units cannot always be correlated on a comparable basis.

The nominal power input values required for full rated load are given in the table where this data was available, with these input values being for optimum load matching in most instances. The no-load power input to the equipment is usually considerably less than the nominal power input value given and for tube equipment may be of the order of about 10 percent of the value given. The power input may be considerably varied by the power factor of the system, the power output and effectiveness of the load coupling method.

The power output given is the maximum nominal power output under load conditions, assuming efficient coupling between the generator and load. When the duty cycle is such that maximum output power is used only a small fraction of the time, output ratings may be exceeded with some units.

The rotating machine types and the mercury-arc frequency converter operate at audio frequencies, with the highest value for rotating machines being about 10,000 cps at present. Such low frequencies are used for induction melting of metals and for induction heating throughout the entire mass of conducting materials.

Most of the vacuum-tube equipment for induction heating operates either at frequencies between 100 and 500 kc or in the region from 2 to 5 Mc. The lower frequency band is usually employed for surface heating operations, case hardening and similar applications.

In dielectric heating generators the operating frequency is usually in the neighborhood of 20 to 30 Mc, although equipment operating up to 200 Mc is available.

Most manufacturers supply the necessary accessories such as output coils, work tables, and similar equipment, in order to assure that the installation operates satisfactorily and efficiently. At the pres

TABLE II. COST-PER-KW COMPARISON FOR EQUIPMENT

Power Output In kw	Vacuum Tube Units	Other Types
1	$1200 to $2200	
2	$500 to $1500	Spark gap units cost $150 to $250 per kw up to 20 kw
5	$250 to $1000	
10	$250 to $1000	
20	$250 to $700	
50	$150 to $700	
100	$100 to $500	Rotating machines cost $50 to $200 per kw from 50 to 1000 kw
200		
500		
1000		

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TABLE I—MANUFACTURERS OF INDUCTION AND DIELECTRIC HEATING EQUIPMENT

Name of Manufacturer	Type of Heating	Type of Generator	Power Input	Power Output	Output Frequency
Ajax Electrothermic Corp., Ajax Park, Trenton, N. J.	Induction	Spark Gap	3 kw	2 kw	40–80 kc
	Induction	Spark Gap	6 kw	4 kw	40–80 kc
	Induction	Spark Gap	20 kw	15 kw	10–40 kc
	Induction	Spark Gap	40 kw	30 kw	10–40 kc
	Induction	Rot. Mach.	———	50 kw	1, 3, or 10 kc
	Induction	Rot. Mach.	———	100 kw	1, 3, or 10 kc
	Induction	Rot. Mach.	———	175 kw	1, 3, or 10 kc
	Induction	Rot. Mach.	———	250 kw	1, 3, or 10 kc
	Induction	Rot. Mach.	———	350 kw	1, 3, or 10 kc
	Induction	Rot. Mach.	———	700 kw	1, 3, or 10 kc
	Induction	Rot. Mach.	———	1200 kw	1, 3, or 10 kc
Allis-Chalmers Mfg. Co., Milwaukee, Wisc.	Induction	Merc. Arc	———	300 kw	1000–3000 cps
	Induction	Merc. Arc	———	600 kw	1000–3000 cps
	Induction	Merc. Arc	———	750 kw	1000–3000 cps
	Induction	Merc. Arc	———	1000 kw	1000–3000 cps
	Induction	Vac. Tube	35 kva	20 kw	400–500 kc
	Induction	Vac. Tube	65 kva	50 kw	400–500 kc
	Induction	Vac. Tube	130 kva	100 kw	400–500 kc
American Type Founders, Induction Heating Division, Union City, N. J.	Induction	Spark Gap	16 kw	15 kw	100–300 kc
	Induction	Spark Gap	———	30 kw	———
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.	Vacuum tube types up to 25 kw output, for both induction and dielectric heating, on a custom basis only at present.				
Budd Induction Heating, Inc., 11811 Charlevoix Ave., Detroit 14, Mich.	Rotating types for induction heating, on a custom basis at present, including complete accessories and tooling.				
Ecco High Frequency Electric Corp., 7020 Hudson Blvd., North Bergen, N. J.	Induction	Spark Gap	3.5 kva	———	50–500 kc
	Induction	Spark Gap	5.5 kva	———	50–500 kc
	Induction	Spark Gap	8 kva	———	50–500 kc
	Induction	Spark Gap	10 kva	———	50–500 kc
	Induction	Spark Gap	16 kva	———	50–500 kc
	Induction	Spark Gap	20 kva	———	50–500 kc
	Induction	Spark Gap	35 kva	———	50–500 kc
	Induction	Spark Gap	105 kva	———	50–500 kc
	Induction	Vac. Tube	———	5 kw	50–500 kc
	Induction	Vac. Tube	———	25 kw	50–500 kc
Federal Electric Co., Inc., Chicago	Induction	Vac. Tube	10 kva	5 kw	450 kc
	Induction	Vac. Tube	32 kva	15 kw	450 kc
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.	Dielectric	Vac. Tube	2 kva	1 kw	27 Mc
	Dielectric	Vac. Tube	6 kva	3 kw	15 Mc
	Dielectric	Vac. Tube	14 kva	7 kw	15 Mc
	Dielectric	Vac. Tube	30 kva	15 kw	27 Mc
	Dielectric	Vac. Tube	50 kva	25 kw	15 Mc
	Induction	Vac. Tube	5 kva	3 kw	15 Mc
	Induction	Vac. Tube	14 kva	7 kw	9–15 Mc
	Induction	Vac. Tube	50 kva	25 kw	2–5 Mc
	Induction	Vac. Tube	50 kva	25 kw	350 kc
	Induction	Vac. Tube	100 kva	50 kw	2–5 Mc
	Induction	Vac. Tube	100 kva	50 kw	350 kc
	Induction	Vac. Tube	150 kva	75 kw	2–5 Mc
Girdler Corp., Thermex Division, 224 E. Broadway, Louisville, Ky.	Dielectric	Vac. Tube	———	0.4 kw	———
	Dielectric	Vac. Tube	———	0.6 kw	———
	Dielectric	Vac. Tube	———	0.75 kw	———
	Dielectric	Vac. Tube	———	1.2 kw	———
	Dielectric	Vac. Tube	———	1.5 kw	———
	Dielectric	Vac. Tube	———	4 kw	———
	Dielectric	Vac. Tube	———	4.5 kw	———
	Dielectric	Vac. Tube	———	8 kw	———
	Dielectric	Vac. Tube	———	16 kw	———
	Dielectric	Vac. Tube	———	25 kw	———
	Dielectric	Vac. Tube	———	150 kw	———
Illinois Tool Works, 2501 N. Keeler Ave., Chicago 39, Illinois	Dielectric	Vac. Tube	———	1 kw	———
	Dielectric	Vac. Tube	3.8 kw	2.5 kw	10–27 Mc
	Dielectric	Vac. Tube	9 kw	5 kw	10–27 Mc
	Dielectric	Vac. Tube	35 kw	20 kw	10–27 Mc
	Induction	Vac. Tube	———	1 kw	2 & 6.65 Mc
	Induction	Vac. Tube	———	2.5 kw	2 & 6.65 Mc
	Induction	Vac. Tube	———	5 kw	2 & 6.65 Mc
	Induction	Vac. Tube	———	20 kw	2 & 6.65 Mc
Induction Heating Corporation, 389 Lafayette St., New York, N. Y.	Induction	Vac. Tube	20 kva	10 kw	375 kc
	Induction	Vac. Tube	38 kva	20 kw	375 kc
	Induction	Vac. Tube	76 kva	40 kw	375 kc
	Dielectric	Vac. Tube	10 kva	3.5 kw	10–35 Mc
	Dielectric	Vac. Tube	20 kva	12.5 kw	10–35 Mc
Intra-Therm Corp., Third and Keo Way, Des Moines 9, Iowa	Vacuum tube types for dielectric heating, in sizes ranging from 1 to 250 kw output power and frequencies from 10 to 100 Mc				
Lepel High Frequency Laboratories, 39 West 60th St., New York, N. Y.	Induction	Spark Gap	4 kw	2.8 kw	150–450 kc
	Induction	Spark Gap	7.5 kw	5.2 kw	150–450 kc
	Induction	Spark Gap	15 kw	10.5 kw	150–450 kc
	Induction	Spark Gap	30 kw	21 kw	150–450 kc
	Induction	Vac. Tube	2.2 kw	———	350 kc
	Dielectric	Vac. Tube	0.5 kw	150 w	80 Mc
	Dielectric	Vac. Tube	2.2 kw	900 w	14 Mc
	Dielectric	Vac. Tube	5 kw	2.3 kw	14 Mc
Ohio Crankshaft Co., 3800 Harvard Ave., Cleveland, Ohio	Induction	Rot. Mach.	15 hp	7.5 kw	9600 cps
	Induction	Rot. Mach.	25 hp	15 kw	9600 cps
	Induction	Rot. Mach.	50 hp	30 kw	9600 cps
	Induction	Rot. Mach.	90 hp	50 kw	9600 cps
	Induction	Rot. Mach.	130 hp	75 kw	9600 cps
	Induction	Rot. Mach.	175 hp	100 kw	9600 cps
	Induction	Rot. Mach.	225 hp	125 kw	9600 cps
	Induction	Rot. Mach.	275 hp	150 kw	9600 cps
	Induction	Rot. Mach.	310 hp	200 kw	3000 cps
	Induction	Vac. Tube	25 kw	20 kw	450 kc
Radio Corp. of America, RCA Victor Division, Camden, New Jersey	Dielectric	Vac. Tube	800 w	100 w	200 Mc
	Induction	Vac. Tube	2.2 kw	750 w	400 kc
	Dielectric	Vac. Tube	5.5 kw	2 kw	27.4 Mc
	Induction	Vac. Tube	5.5 kw	2 kw	400 kc
	Dielectric	Vac. Tube	40 kw	15 kw	2, 5, or 10 Mc
	Induction	Vac. Tube	40 kw	15 kw	400 kc
	Dielectric	Vac. Tube	110 kw	60 kw	13.7 Mc
	Induction	Vac. Tube	135 kw	75 kw	400 kc
	Dielectric	Vac. Tube	225 kw	125 kw	13.7 Mc
	Induction	Vac. Tube	260 kw	150 kw	400 kc
Radio Receptor Co., 251 West 19th St., New York, N. Y.	Dielectric	Vac. Tube	———	500 w	5, 15, or 30 Mc
	Dielectric	Vac. Tube	———	1 kw	5, 15, or 30 Mc
	Dielectric	Vac. Tube	———	2.5 kw	5, 15, or 30 Mc
	Dielectric	Vac. Tube	———	5 kw	5, 15, or 30 Mc
	Dielectric	Vac. Tube	———	7.5 kw	5, 15, or 30 Mc
	Dielectric	Vac. Tube	———	15 kw	5, 15, or 30 Mc
	Dielectric	Vac. Tube	———	30 kw	5, 15, or 30 Mc
"S" Corrugated Quenched Gap Co., Scientific Electric Division, 111 Monroe St., Garfield, N. J.	Dielectric	Vac. Tube	———	3 kw	15–40 Mc
	Dielectric	Vac. Tube	———	5 kw	15–40 Mc
	Dielectric	Vac. Tube	———	8 kw	15–40 Mc
	Induction	Vac. Tube	———	5 kw	200–600 kc
	Induction	Vac. Tube	———	7.5 kw	200–600 kc
	Induction	Vac. Tube	———	10 kw	200–600 kc
	Induction	Vac. Tube	———	12.5 kw	200–600 kc
	Induction	Vac. Tube	———	18 kw	200–600 kc
	Induction	Vac. Tube	———	25 kw	200–600 kc
	Induction	Vac. Tube	———	40 kw	200–600 kc
	Induction	Vac. Tube	———	60 kw	200–600 kc
Westinghouse Electric Corp., East Pittsburgh, Pa.	Ind. & Diel.	Vac. Tube	———	1 kw	300 kc & 10 Mc
	Dielectric	Vac. Tube	6.25 kva	2 kw	5, 15, or 30 Mc
	Ind. or D.	Vac. Tube	11 kva	5 kw	0.45, 5, 15, or 30 Mc
	Ind. or D.	Vac. Tube	21 kva	10 kw	0.45, 5, 15, or 30 Mc
	Ind. or D.	Vac. Tube	43 kva	20 kw	0.45, 2, or 10 Mc
	Induction	Vac. Tube	95 kva	50 kw	0.45 Mc
	Induction	Rot. Mach.	———	50 kw	3000 & 9600 cps
	Induction	Rot. Mach.	———	75 kw	9600 cps
	Induction	Rot. Mach.	———	100 kw	3000 & 9600 cps
	Induction	Rot. Mach.	———	125 kw	9600 cps
	Induction	Rot. Mach.	———	150 kw	3000 cps
	Induction	Rot. Mach.	———	200 kw	3000 cps

ent time some of this equipment (especially the work coils) are more or less custom built.

Because various makes of units differ in their fundamental designs, complexity, quality of manufacture, and accessories, it is difficult to provide an equitable comparison of overall costs of various types of generating equipment. Usually direct consultation with the manufacturer, outlining specifically and completely the problem to be met by the generating equipment, is required in order that reasonably accurate cost estimates can be made. However, on the basis of commercial equipment now available and installations now in operation it is possible to indicate a range of probable costs of such equipment, as in Table II. As given here, the cost applies only to the generating equipment and is based on the cost per kilowatt of output rating for the various types of generators now in use.—B. D.

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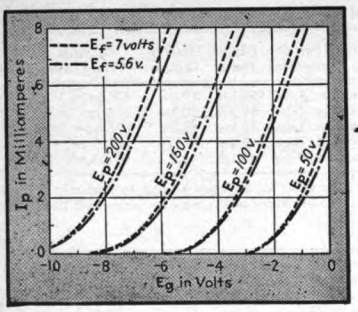

FIG. 1—Effect of filament voltage on characteristics of a 6SN7GT/G tube

SURVEY OF

Analysis of causes of drift in direct-current amplifiers, descriptions of methods used to neutralize or prevent drift, and typical industrial applications

By MAURICE ARTZT

RCA Laboratories
Princeton, N. J.

THE quest for a stable d-c amplifier is an old one, and will probably continue as long as tube characteristics wander with changes in voltage and temperature. A rapidly expanding literature on the subject gives evidence that considerable progress has been made in overcoming drifts and instabilities usually associated with d-c amplifiers. As their advantages in certain applications become more apparent, still further progress is to be expected.

It was originally intended that this article would be a few brief notes describing a new type of d-c amplifier, but for a number of reasons these original notes have been expanded to include a discussion of the causes of drift, and also a brief description of various methods of either neutralizing or preventing it. The original use of this new amplifier has become of secondary importance in comparison with its adaptation as a cathode-ray deflection amplifier. As square-wave testing and electronic switching techniques are more widely adopted, this and other applications for d-c amplifiers will become increasingly more important. Accordingly, it is felt that a more general survey of d-c amplifiers is justified at this time.

An attempt has been made to provide relatively complete references to literature on the subject. However, it is possible that important references have been omitted because the available material is widely scattered.

Causes of Drift

There are three primary causes of zero or steady-state drift in the usual d-c amplifier circuit. The first of these, and the one easiest to eliminate, is drift due to changes in the plate supply voltage. This can be balanced out by either of two methods: by complete regulation of the B supply, or by devising a tube circuit in which the plate current is exactly proportional to the B voltage. Where regulation of the B supply is the method chosen it can usually be carried to as high an accuracy as needed, though this results in a rather bulky unit.

The second method is to be preferred wherever possible, for it permits the use of an unregulated voltage supply. It can be readily seen

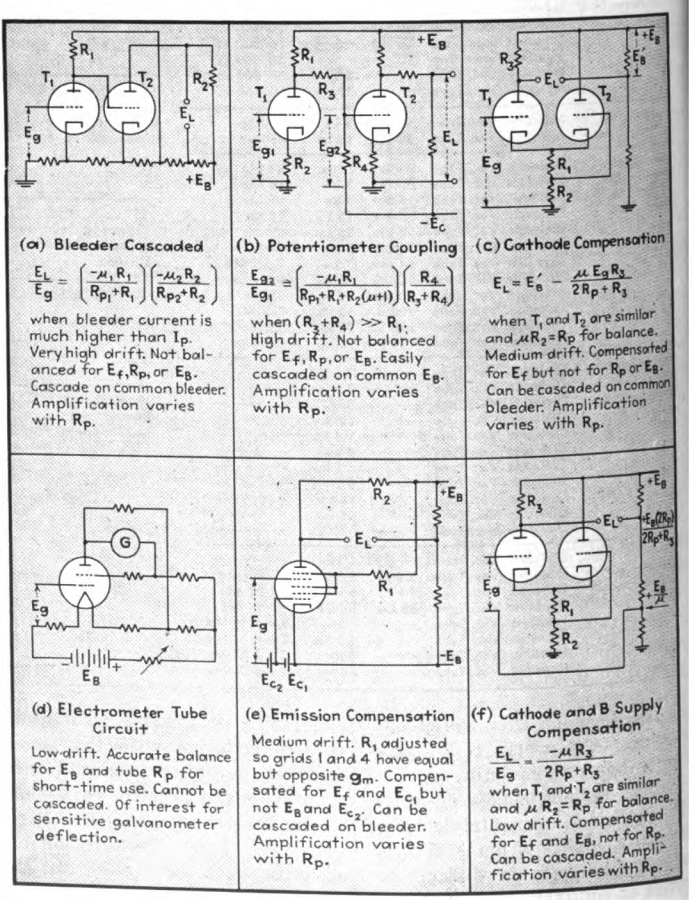

FIG. 2—Fundamental and compensated d-c amplifier circuits

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D-C AMPLIFIERS

that when the plate current of a tube is exactly proportional to the B voltage, then the voltage developed between the plate of this tube and a proper tap on a B supply bleeder will remain zero as the B voltage varies. A bridge balance is thus substituted for an accurately regulated source of plate power.

The other two causes of drift are directly related and result from changes in cathode temperature. The first of these—contact potential—is the most troublesome, and has an effect similar to a change in grid bias as cathode temperature changes. This same change in cathode temperature will also cause the equivalent plate impedance of the tube to vary. But these two characteristics do not change by a definitely fixed amount with cathode temperature. They both have rather large components interrelated with plate current and plate voltage.

Where the tube is used only in the center of its linear range, and excursions in plate current due to signals are small, then the R_p of the tube can be considered constant and the effect of these two variables lumped and treated as a shift in grid bias with cathode temperature. Where the operating conditions are not so limited, both must be considered. This is readily seen in the voltage-current equations of a tube.

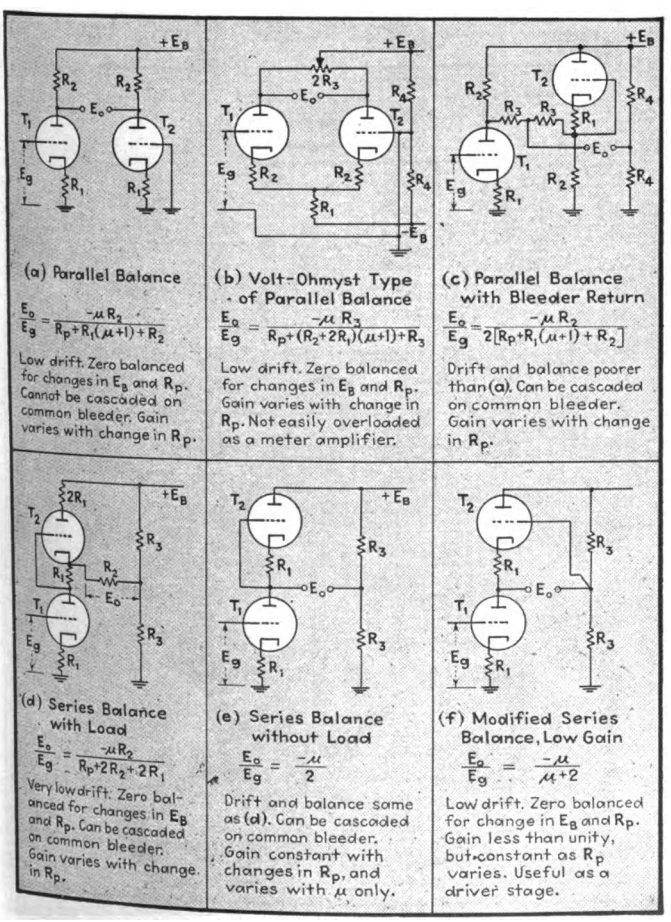

FIG. 4—Fundamental circuits of balanced d-c amplifiers

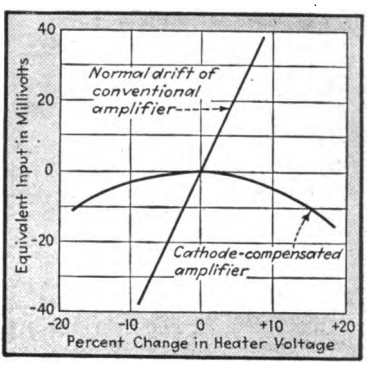

FIG. 3—Characteristic of cathode-compensated d-c amplifier circuit shown in Fig. 2 (c)

It is usual to express the voltage-current equation of a tube as follows

$$i_p = \left[\frac{E_p + \mu E_g}{R_p}\right]^n \qquad (1)$$

For a limited operating range in the linear portion of the tube curves, the exponent n can be considered to be unity, and R_p can be considered as the slope of the E_p/i_p curve at this point. This is usually written then as

$$E_p = i_p R_p - \mu E_g \qquad (2)$$

The contact potential drift can then be added as a voltage V_f, varying with filament voltage, to give the expression

$$E_p = i_p R_p - \mu E_g + \mu V_f \qquad (3)$$

This equation can be used over a limited range in deriving the expression for overall performance of an amplifier, and will give a reasonably accurate indication of the drift to be expected as V_f changes. It is so used in deriving the balance conditions and gain equations for a number of the d-c amplifier systems described later.

That Eq. (3) cannot possibly hold over any large range of voltage variations is shown by the tube curves in Fig. 1. This set of curves was taken on one of the triodes in a 6SN7GT/G tube of average g_m. The curves are definitely moved to the left in the linear range by an increase in filament voltage, and this gives some weight to the use of the contact potential drift voltage

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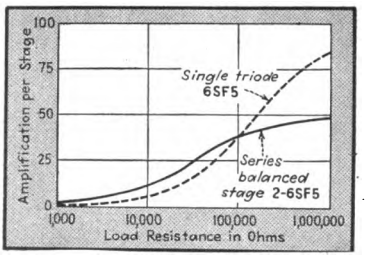

FIG. 5—Variation of amplification with load resistance for a single triode stage and a two-tube series-balanced stage. In both instances no bypass capacitor was used on the cathode bias resistor

V_f assumed in Eq. (3). But account is not taken of the fact that the slope of the curves also changes, for apparently R_p has decreased as E_f was increased. What has actually happened in Eq. (1) for this change in filament voltage is that the exponent n has changed, for the tangent point of intersection of the curves in Fig. 1 has not shifted appreciably. The two sets of curves become more nearly parallel at the higher values of I_p, so Eq. (3) becomes increasingly more accurate as I_p increases.

From these tube curves and equations it may be seen that while drifts due to B supply are a first-order effect, those due to cathode temperature are considerably more complicated, and greater care in design is necessary for their elimination.

The four general classifications of d-c amplifiers are (a) simple cascaded amplifiers, (b) modulation systems, (c) compensated d-c amplifiers, and (d) bridge-balanced d-c amplifiers. Each type will be briefly described in turn here.

Simple Cascaded Amplifier

In the simple cascaded amplifier, succeeding stages are usually stepped up a B supply bleeder, or coupled with a potentiometer divider with consequent loss in gain. These are illustrated in Fig. 2(a) and 2(b) and, supplied with unregulated voltages, are notorious for drift. They are seldom used without some form of correcting or compensating system.

One form of drift control can be obtained by adding 100-percent degenerative feedback to obtain a current amplifier with unity voltage gain. This circuit is so applied in a commercial sensitive microammeter.[1]

The circuit in Fig. 2(b) has been used in various ways with feedback[2] and with correction for the loss in voltage gain,[3, 4] but in either case careful regulation of plate and filament supplies is required to eliminate drift.

Modulation Systems

While modulation systems are not strictly d-c amplifiers, they are so used in many applications and have considerable merit. In this type the d-c signal to be amplified modulates a carrier wave, and after sufficient amplification the wave is detected to obtain the amplified signal. Such systems are well known and the literature is fairly complete.[5, 6, 7]

Where the required frequency response is very high, these systems become awkward because the high carrier frequency requires elaborate shielding. It is therefore more limited in its applications than the two types that follow.

In a modified form, the input signal itself is chopped. This can be done by a light shutter for phototube amplifiers, or by vibrators or tubes for other types of signals.[7]

In compensated d-c amplifiers some variable characteristic of the amplifying tube is balanced against the same variations in another tube, or against a different characteristic of the same tube. This system compensates for contact potential drift in the cathode-coupled amplifier system, as illustrated in Fig. 2(c).[9, 10, 11, 12, 13] When used with an accurately regulated power source a stable system results.

Compensated D-C Amplifiers

This cathode-compensated amplifier can be considerably improved and still greater freedom from drift obtained if the input voltage includes a tap on the B supply bleeder at the value of E_b/μ, as shown in

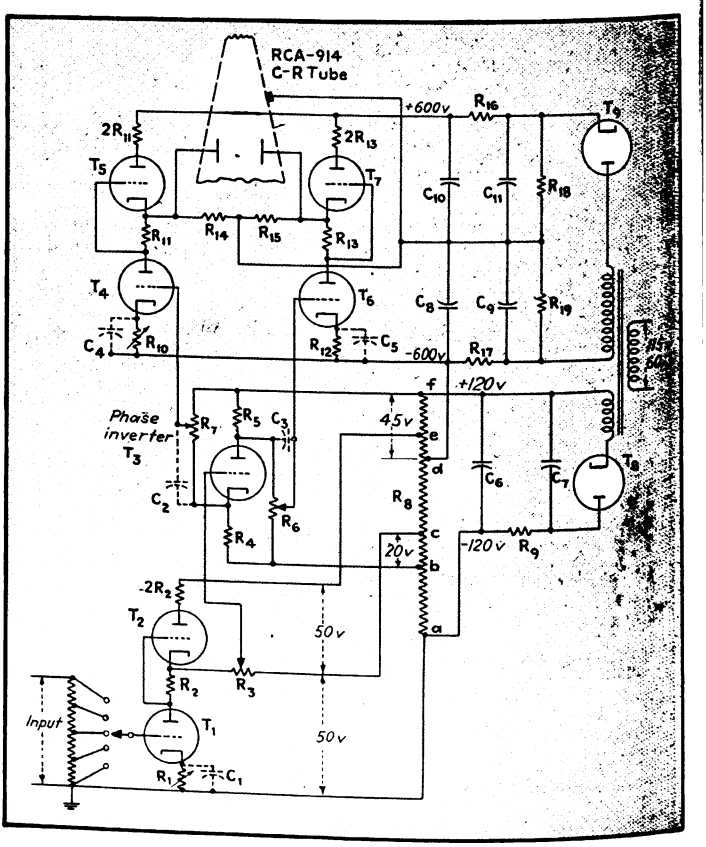

FIG. 6—Series-balanced d-c amplifier circuit arranged for feeding a pair of deflecting electrodes in a cathode-ray tube of an oscilloscope

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Fig. 2(f). This addition makes the zero-signal output current directly proportional to plate voltage. When the output is then returned to the proper point on the bleeder, the effect of changing E_s is eliminated, and the plate supply need not be regulated.

The drift characteristic of amplifiers of this type as compared to a conventional amplifier is shown in Fig. 3. The balance obtained is a tangential one, and holds over only a limited range of filament supply variation. For this reason, even with E_s compensation as in Fig. 2(f), only a limited supply voltage change can be allowed if resetting of the zero point is to be avoided.

By a fortunate choice of constants this compensation for filament and plate voltage can be obtained in the amplifying tube itself, as in the electrometer tube circuits.[14, 15] One form of this circuit is shown in Fig. 2(d). As this circuit cannot be readily cascaded, it is chiefly of interest for use with a sensitive galvanometer.

Compensation for changes in emission, whether due to heater voltage change or to a random effect, can be obtained in a pentagrid type of tube as shown in Fig. 2(e)[16]. Here the value of R_1 is adjusted to make grids 1 and 4 have equal but opposite transconductance to the plate, and the compensation therefore includes all circuit elements common to both grids, but does not include the plate supply. In this circuit, as in the cathode-compensated circuits, with the two control grids having equal but opposite effects on the plate current, signals can be applied to either grid, or to both at the same time to obtain a differential amplifier. If grid 4 in Fig. 2(e) is returned to a tap on a bleeder across the plate supply, correction for changes in E_s will be obtained in a manner similar to that applied to the circuit in Fig. 2(f).

While this brief resume of compensating systems is not complete, it includes the better known methods and will serve to illustrate how compensation for filament supply can be obtained, and show that compensation for plate supply can usually be added for increased stability.

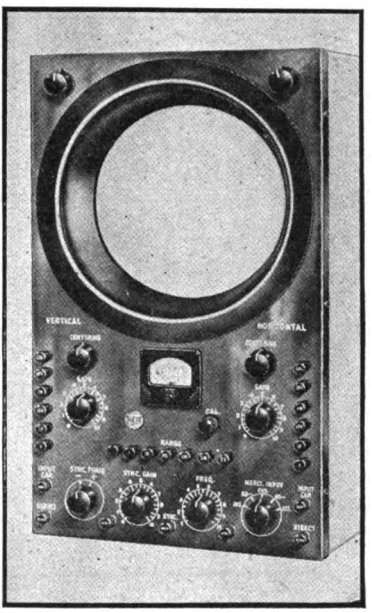

FIG. 7—RCA 327A oscilloscope, which uses a series-balanced d-c amplifier circuit

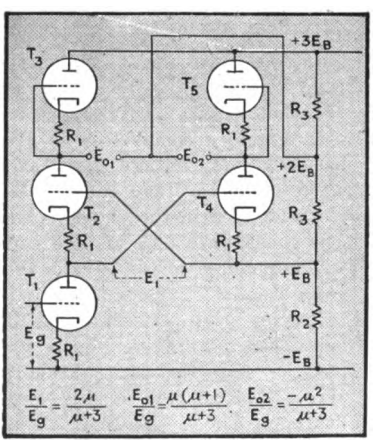

FIG. 8—Circuit illustrating use of the modified series-balanced low-gain driver stage of Fig. 4 (f) to obtain push-pull output from single-ended input

A distinction is made between compensated and bridge-balanced d-c amplifiers, for in bridge-balanced circuits all variables in the amplifying arm, including tube characteristics and supply voltages, are balanced against similar variables in a second arm of the bridge. Thus if the parameters of the non-amplifying arm vary in the same manner as those in the amplifying arm, a complete balance for E_f, E_s, R_p and contact potential is obtained. While it may be argued that no two tubes will balance for all of these changes, it has been found experimentally that such a balance is no more difficult to obtain than the balance for contact potential alone as used in the compensated circuits.

Bridge-Balanced D-C Amplifiers

The advantages of this type of balance are that regulation of plate and filament supplies becomes unnecessary except where extreme precision is required, and the balance holds for any part of the tube curves. Operation becomes less critical and more consistent.

The conventional type of balanced d-c amplifier is shown in Fig. 4(a). It is the equivalent of returning the output voltage to a bleeder in which the bleeder proportioning changes in the same manner as the amplifying tube. This type of amplifier will balance perfectly if the two tubes remain identical in characteristics as supply voltages change. It is often used in tube voltmeter circuits.[17]

A modification of this circuit, in Fig. 4(b), is found in the well-known Volt-Ohmyst circuit for voltage and resistance measurements.[18] While having some of the features of the cathode-coupled circuits, the main balance is still between the two tubes in parallel, with the common coupling resistor R_1 assisting in maintaining a constant zero position.

Neither of these two circuits can be cascaded as shown, and both are most useful as meter amplifiers, etc. Where higher gain is required than one stage will give, the circuit in Fig. 4(a) can be modified to that in Fig. 4(c) to allow cascading. The output then is returned to the B supply bleeder and additional stages can be stepped up the bleeder in the usual manner. In this case the gain per stage has been cut in half from that of the circuit in Fig. 4(a), and the high-frequency response has been impaired by the high value of series resistors R_s that feed the output. For proper balance the circuit requires that four pairs of resistors as well as the tubes remain constant and it will therefore have slightly more drift than the circuit of Fig. 4(c) under similar conditions.

These disadvantages in Fig. 4(c)

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can be eliminated and several important advantages gained by shifting T_2 and its cathode resistor over to replace the plate resistor for T_1 as shown in Fig. 4(d) and 4(e).[19] Here the balance is no longer for tubes in parallel, but rather in series, and both pass the same plate current at the zero-signal position. The balance for changes in E_b and R_p is more nearly perfect than in Fig. 4(a), 4(b), and 4(c). A differential change in contact potential between the two tubes will shift the zero position as in any other balanced arrangement, but with the same plate current in each tube this effect is much less pronounced than in the parallel systems.

If the value of load resistor R_2 is low, somewhat higher amplification will be obtained with the circuit in Fig. 4(d) than with the simplified version in Fig. 4(e). In Fig. 4(d) the load current flows through the cathode resistor of T_2 in a regenerative direction. However, for all practical purposes, if a load resistor equal to or greater than the R_p of the tubes is used, there is little difference and the simpler arrangement of Fig. 4(e) with its fewer parts is preferred.

In both Fig. 4(d) and 4(e) the cathode resistor of T_1 is usually made variable as a balance adjustment. The range of adjustment is purposely made small, ±15 percent from the value of the cathode resistor of the upper tube. Under these conditions it has been found that if R_1 can be set within this range so that $E_o = 0$ with no input to the grid of T_1, the two tubes are sufficiently well matched for all practical purposes, and hold this balance over very wide changes of filament and plate voltages. When properly balanced in this manner a sensitive voltmeter can be connected across E_o and will show no deflection even when the line voltage supplying filament and plate power is switched off and on.

A third arrangement of the series-balanced system is shown in Fig. 4(f). Here the upper grid is returned to the bleeder instead of to the plate of T_1, and the voltage gain is reduced to slightly less than unity. This is useful as a current amplifier for meters, or as a driver stage for a succeeding cascaded push-pull arrangement discussed later. Its drift is slightly more than the true series systems of Fig. 4(d) and 4(e), but is still very low.

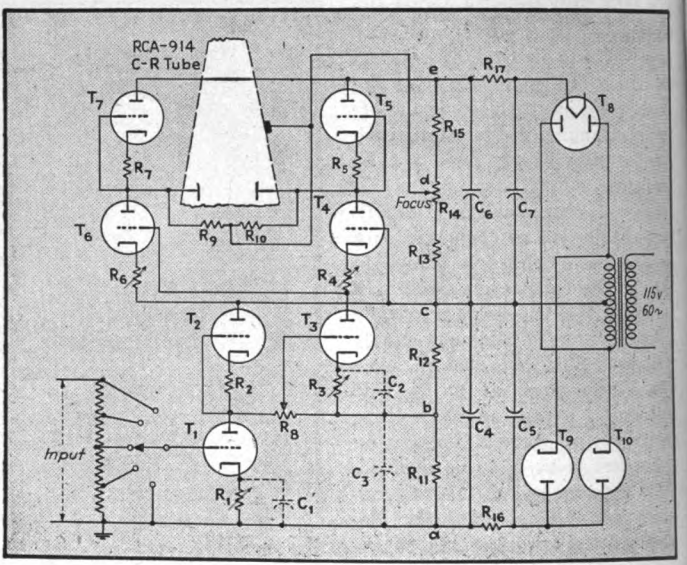

FIG. 9—Alternative method of using a series-balanced d-c amplifier for oscilloscope deflection

In Fig. 5 a comparison is given between the voltage gain of a series-balanced stage and of a single tube used in the usual manner. The tubes were 6F5 in both cases, with 1000-ohm self-biasing cathode resistors, not bypassed. For low values of load resistance the balanced stage will give higher gain, but for high-resistance loads the single tube has the greater amplification. The upper limit of gain for the balanced stage is $\mu/2$, or 50 in this case, and it reaches very nearly this value with loads three or more times the plate resistance.

Oscilloscope Deflection Amplifiers

Two types of deflection amplifiers have been built using the basic series-balanced amplifier circuits shown in Fig. 4(d), 4(e), and 4(f). The first of these is shown in Fig. 6 and is used with minor modifications in the RCA-327A Oscilloscope shown in Fig. 7.

The output stage consists of four 6SF5 tubes in push-pull balance and supplied from a 600-volt power supply, non-regulated and only half-wave rectified. This stage is driven from T_3, a 6J5 used as a phase inverter. The inverter stage obtains its plate power from the bleeder on a second d-c source of 120 volts, again unregulated and half-wave rectified. The input stage, employing 6SF5 tubes for T_1 and T_2, draws plate power from the same low-voltage bleeder that feeds the phase inverter. This bleeder is 10,000 ohms and has fixed taps providing the voltages shown. No bypassing is used between any taps on the bleeder. This prevents any one section from having a different time delay on build-up or decay with a changing line voltage. Half-wave rectifying for the two power supplies is possible because all hum is balanced out for the zero-signal condition, and rises to only a few percent when sweeping a nine-inch screen.

The process of balancing the amplifier is simple, and the cathode-ray tube itself is used as the indicator. The two load resistors, R_{14} and R_{15}, are shorted, and the zero position of the cathode-ray spot is marked. The grid of T_4 is then shorted to minus 600 volts and the short on R_{14} removed. R_{10} is adjusted to bring the spot back to its zero position. Then the grid of T_5 is shorted to minus 600 volts, the short on R_{15} removed, and R_{13} adjusted to recenter the spot.

The output stage is now balanced and the phase inverter can be ad-

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justed. Short R_3 so the inverter has zero input, remove the short between the grid of T_4 and minus 600 volts, and adjust R_7 to center the spot, then remove the short on the grid of T_6 and adjust R_6 to again center the spot. Now with the input control at zero, the short across R_3 can be removed and R_1 finally adjusted to center the spot again. The entire amplifier is now balanced and ready for use.

The amplifier as described will have a flat response from pure direct current to over 20,000 cycles. By the addition of the five capacitors shown in dotted lines, the upper limit is raised to over 100,000 cycles. The values of these are determined by the circuit constants and the various capacitances to ground.

In use this amplifier shows remarkable stability of image, there being no breathing with widely changing line voltages, and no capacitance couplings to cause transients that jump the image off the screen on change of input. Turning off the power and later turning it on causes the image to fade out and then fade in without appreciably changing location on the screen.

It has been found that with the oscilloscope in daily use for many hours at a time any readjustment of balance was unnecessary for periods of six months or more, and the spot position over this time and from cold to hot never varied over 0.1 inch. As the deflection sensitivity is approximately 0.1 volt per inch, this shows an overall long-time drift of not over 10 millivolts as referred to the input. When it is considered that ordinary tubes and resistors are used and that neither plate nor filament supplies are regulated, this performance becomes remarkable.

Push-Pull Driver for Oscilloscope

A second type of deflection amplifier was built with the stage shown in Fig. 4(f) as a push-pull driver. The method of obtaining push-pull from this driver is shown in detail in Fig. 8. Here the driver tube T_1 passes the full plate current of that side of the output having tubes T_2 and T_3 in series. As the grid of T_6 is connected to the B supply bleeder, it forms a cathode drive for T_5. At the same time the second half of the output stage has the lower cathode returned to the bleeder and the lower grid is driven by T_1. Thus T_2 and T_4 are driven in opposite phase to obtain push-pull output. While the balance of zero position is correct with this type of drive, the two output voltages E_{o1} and E_{o2} are not quite the same, but differ by the ratio of $(\mu + 1)/\mu$. However, this is not serious, as it amounts to only three percent with 6SH7 tubes as triodes in the output stage. This is as close to a true balanced push-pull as is ordinarily obtained in any circuit unless the tubes are especially picked.

The complete deflection amplifier

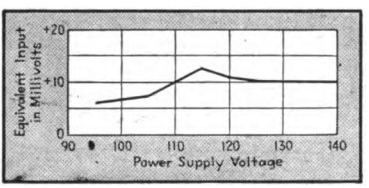

FIG. 10—Effect of variations in power supply voltage on drift in the oscilloscope deflection amplifier of Fig. 9

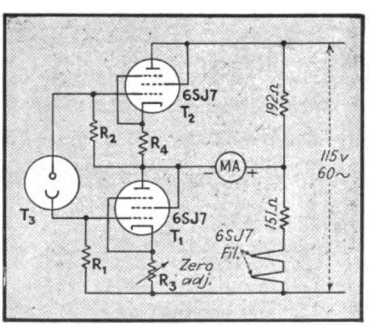

FIG. 11—Series-balanced amplifier used as a light meter

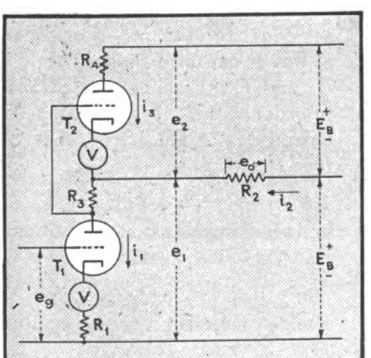

FIG. 12—Derivation of series-balanced conditions in an amplifier

with this drive system is shown in Fig. 9. This second system has the advantage over the first that the two plate power sources are connected plus to minus rather than at an intermediate point as in Fig. 6. Thus both upper and lower supplies can be obtained from a single power transformer winding. In addition the driver stage has nearly unity gain, rather than a 2 to 1 loss as in the phase inverter, so additional sensitivity can be obtained.

This amplifier was built with 6SJ7 tubes for T_1 and T_2 and 6SH7 tubes for T_3, T_4, T_5, T_6, and T_7. All were connected as triodes with suppressor and shell connected to cathode, and screen to plate. The four bleeder voltages *ab*, *bc*, *cd*, and *de* are equal, and in this case 300 volts each. The three capacitors shown dotted bring the flat response up to 250,000 cycles, with a slow drop-off above this. The amplifier is usable at 500,000 cycles with about fifty percent of the deflection at zero frequency or direct current.

Comparison of Oscilloscope Circuits

The balance conditions obtained with the circuit of Fig. 9 are not quite as good as in the first method because tube T_3 must balance through T_6 and T_7 in series, but the spot is still within 0.2 inch of its cold position after an eight-hour run. The deflection sensitivity is less than for Fig. 6, as tubes with a lower μ are used to get better high-frequency response.

One precaution is necessary here that was unnecessary with the first amplifier; namely, adjustment of the time constants of the two power supplies to be equal and thus prevent breathing with line voltage changes. As upper bleeder *cde* has the heavier tube load across it, the overall value of R_{11} and R_{13} must be somewhat less than the sum of R_{13}, R_{14}, and R_{15}. The value is easily determined by using a Variac in the supply line, and adding additional load from *a* to *c* until breathing is eliminated with sudden line changes. Once determined, a fixed load can be put across *a* to *c*, as this is not critical and need not be made variable for future adjustments.

The drift performance of this amplifier with changes in line voltage is shown in Fig. 10, where the

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equivalent input in millivolts is plotted against the power line voltage. Between the line voltage limits of 105 to 140 volts this drift is only ±2.5 millivolts, and represents a spot movement of ±0.008 inch on the nine-inch screen. This is considerably better than is obtained with most a-c deflection amplifiers even with carefully regulated plate supplies.

Both of these deflection amplifiers are shown without the usual centering control. The resistor R_1 is used for centering in either case by throwing the amplifier off balance the required amount to move the zero position of the spot anywhere on the screen. This is an instantaneous movement and does not have the high time delay of motion obtained with the centering control on an a-c deflection amplifier.

In both amplifiers the second anode of the cathode-ray tube is above ground, by 375 volts in Fig. 6 and by 900 volts in Fig. 9. This voltage, therefore, adds to the usual high negative voltage supplying the cathode of the cathode-ray tube to give the total cathode-to-anode accelerating voltage. The reason for not grounding the second anode is, of course, to allow one side of the signal input to be grounded.

Photoelectric Light Meter

One interesting application of the series-balanced circuit should be noted. This is a light meter that can be calibrated as an exposure meter or the like. The circuit in Fig. 11 is almost self-explanatory, for the two tubes are operated as in the other circuits described, but with a-c plate supply. The phototube is connected grid to grid to obtain additional amplification. The two grid resistors are equal and one megohm each, and the meter is one milliampere full scale. R_4 is 500 ohms and R_3 is 400 ohms fixed and 200 ohms variable.

With this arrangement and with an RCA 918 phototube, a full-scale deflection can be obtained with 0.1 lumen through a $\frac{3}{8}$-inch diameter aperture. Other scales can be provided by switching meter shunts, grid resistors, or apertures. As no transformers or rectifiers are used, a compact instrument results.

Sample Algebraic Treatement

The algebraic derivation of the relationship of output to input voltages in the circuits shown is simple when Eq. (3) is used to represent tube performance. As an example, the formula for the series-balanced amplifier in Fig. 4(d) can be developed as follows:

Consider the circuit as shown in Fig. 12 with the contact potential drift of each tube inserted as the voltage v in each cathode lead. It is assumed for both tubes T_1 and T_2 that these two voltages v, as well as the tube constants μ and R_p, are equal for the balanced condition.

Under these conditions the voltage across the tube T_1 will be, according to Eq. (3)

$$e_{p1} = i_1 R_p - \mu[e_g - v - i_1 R_1] \quad (4)$$

$$\text{Then } e_1 = e_{p1} + i_1 R_1 + i_1 R_3 + v = i_1[R_p + \mu R_1 + R_1 + R_3] + v[\mu + 1] - \mu e_g \quad (5)$$

$$\text{But } i_1 = i_2 + i_3 \quad (6)$$

$$\text{and } E_B = e_1 + i_2 R_2 \quad (7)$$

Combining Eq. (5), (6), and (7) and solving for i_3

$$i_3 = \frac{E_B - v(\mu + 1) + \mu e_g - i_2(R_p + \mu R_1 + R_1 + R_2 + R_3)}{R_p + \mu R_1 + R_1 + R_3} \quad (8)$$

Now, also by Eq. (3), the voltage across T_2 is

$$e_{p2} = i_2 R_p - \mu[o - i_1 R_3 - v] \quad (9)$$

Substituting for i_1 its value from Eq. (6)

$$e_{p2} = i_2[R_p + \mu R_3] + i_3 \mu R_3 + v[\mu + 1] \quad (10)$$

$$\text{Now } e_2 = e_{p2} + v + i_3 R_4 \quad (11)$$

$$\text{and } E_B = e_2 - i_2 R_2 \quad (12)$$

Combining Eq. (10), (11), and (12) and solving for i_3

$$i_3 = \frac{E_B - v(\mu + 1) - i_2[\mu R_3 - R_2]}{R_p + \mu R_3 + R_4} \quad (13)$$

Now Eq. (8) and (13) can be set equal to each other to solve for i_2, but it can also be seen that both E_B and v will cancel out of the expression for i_2 if the two denominators are equal. For this to be true

$$\mu R_3 + R_4 = \mu R_1 + R_1 + R_3 \quad (14)$$

and the simplest method of making Eq. (14) true is with

$$R_3 = R_1 \text{ and } R_4 = 2R_1 \quad (15)$$

Under these conditions, combining Eq. (8) and (13) gives

$$i_2 = \frac{\mu e_g}{R_p + 2R_1 + 2R_2} \quad (16)$$

and the voltage e_o must therefore be

$$e_o = \frac{\mu e_g R_2}{R_p + 2R_1 + 2R_2} \quad (17)$$

The circuit now balances so that the output voltage e_o is directly proportional to e_g, and is not affected by contact potential v or plate supply voltage 2 E_B (as long as e_o returns to the center of the B supply).

One interesting thing brought out in Eq. (13) is that when the load resistor R_2 has the critical value of $R_2 = \mu R_3$, the current i_3 through T_2 does not change with signal, but holds a constant value, and only i_1 and i_2 change with signal.

When the load resistor R_2 becomes infinite, Eq. (17) reduces to the simplest form and has the highest gain

$$e_o = \mu e_g/2 \quad (18)$$

This same simple algebraic treatment has been used to derive the expressions given under the circuits shown in Figs. 2, 4 and 8.

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Typical inductor iron-core shapes. In the upper right corner is a Hipersil loop; the others, recognizable from their shapes, are E-E, M, E-I, F and L laminations

High-Q Iron-Cored Inductor Calculations

From analytic development, equations for the conditions at which inductor Q will be at its highest are derived. Using these equations, core and coil dimensions for an iron-cored inductor are calculated and the effects of varying its parameters are studied

By STEPHEN L. JAVNA

Chief Engineer
Magnetic Devices Company
New York, N. Y.

IRON-CORED audio-frequency inductors of good Q can be designed with reasonable accuracy, and their performances over a range of frequency and voltage can be predicted by the method to be described herein. Intuition regarding these matters develops with experience, and model theory may be applied, nevertheless it is desirable to approach the subject from an analytical point of view.

Literature is replete with general information on the subject but there does not seem to be a completely organized method of solution. It is the object of this paper, therefore, to present a "cook-book" method for inductor design aimed at obtaining a design that will give an optimum value of Q.

The approach is to write down all pertinent equations, making a few simplifying assumptions so that all the variables that enter into them will be analytic. These equations are substituted, one into another, and the result then differentiated and equated to zero in such a manner as to obtain the optimum design conditions. Thus, although the final design equations are suitable for blind substitution of the given coil parameters and direct solution for the remaining parameters, they will be based on mathematical development.

Design equations for direct substitution simplify such design problems as determining the manner in which each coil dimension affects the coil Q, and thus aid in determining the changes in design that will lead to the required inductor improvements.

The utility of the equations has been tested in design by comparing the calculated with the measured characteristics.

The development will be directed toward finding an answer to the following problem.

Given: Required inductance
Maximum allowable coil dimensions
Operating voltage
Operating frequency
No d-c in the coil

To find, for a condition of optimum Q:

Number of turns
Wire size

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Lamination size and stack
Lamination material
Q
Effect of parameters on Q and inductance

Inductor Construction

Generally speaking, inductors used in communication equipment such as wave filters include a coil of wire that is wound over a suitable form in a manner described elsewhere.[1] The coil is mounted over an iron core which among other forms may comprise a toroidal dust core, Hipersil loop, conventional E-I laminations, or any one of the innumerable other lamination forms and shapes, none of which affects the design procedure.

A popular and easily available shape is the scrapless E-I lamination. These are so called because two Es and two Is are stamped simultaneously from a single blank as shown in Fig. 1(a), with no scrap. Fig. 1(b) gives the dimensions of a choke coil utilizing scrapless laminations of such a quantity as to provide a square cross-sectional area of magnetic path. These laminations are described in greater detail in manufacturers' handbooks.[2]

Table I.—Symbols for coil and core parameters used in the text

A	— Effective cross-sectional area of magnetic-flux path, in square inches
A_g	— Gross cross-sectional area of magnetic path, in square inches
a	— Empirical constant, see Eq. (1)
B	— Maximum flux density within the core, in maxwells per square inch
c	— Area of coil conductor, in square inches
F	— Fraction of core-window area occupied by copper wire of coil
	— Frequency, in cycles per second
g	— Actual gap length, in inches
	— Current through coil, in amperes
k	— Empirical constant, see Eq. (1)
L	— Inductance of iron-cored coil, in henrys
	— Mean length of magnetic path, in inches
L'	— Length of coil conductor, in inches
m	— Mean length of a turn of the coil, in inches
$\mu\Delta$	— Incremental permeability of core with respect to air at operating frequency, in gilberts per inch
N	— Number of turns in coil
n	— B&S wire size number of conductor
R_{a-c}	— Apparent alternating-current coil resistance caused by core loss, in ohms
R_{d-c}	— Copper-loss resistance, in ohms
R'	— Reluctance of air gap assuming no fringing, in gilberts per maxwell
ρ	— Resistivity of conductor, on ohm-inches (0.6788 × 10^{-6} for copper)
	— Total lamination window area, in square inches
t	— Tongue width, in inches, see Fig. 1(a)
V	— Voltage across coil, in volts
w	— Weight of core, in pounds

A magnetic path of square cross-section is desirable because it can be shown that for a given cross-sectional area of magnetic path, the rectangular configuration which gives the shortest mean length per turn of wire is a square. Due to burrs and scale on the laminations, the effective or net cross-sectional area of the stack and tongue width is about 0.9 of this product.

Laminations may be stacked by interleaving, or by stacking all the E pieces in the same direction, and butting the I pieces against them as shown in Fig. 1(b). If an air gap is required, a nonmetallic gap spacer of proper thickness is inserted in the joint between each E and I, and the assembly mechanically clamped together. The coil is always designed to fill the window of the closed lamination, as Fig. 1(c) indicates.

Development of Design Equations

At a given set of conditions of frequency and voltage the equivalent circuit of an iron-cored inductor may be represented by Fig. (2). R_{a-c} is a fictitious value of resistance which, if multiplied by the square of the coil current, will give the core loss of the inductor. Thus, the losses in the inductor may be represented by $I^2R_{d-c} + I^2R_{a-c}$, where I^2R_{d-c} includes copper losses, and I^2R_{a-c} includes core losses.

In developing design equations, we will first derive expressions for the alternating-current and direct-current resistances of the inductor. By combining these two resistance equations with the equation for the Q of the inductor, we will obtain the design equations.

To determine the alternating-current resistance let us assume that core loss of an inductor can be expressed in the form

$$P_{cl} = kB^a \text{ watts per pound} \quad (1)$$

Quantities represented by symbols used in this and subsequent equations are given in Table I. Total core loss in the inductor is then

$$P = kB^a w \text{ watts} \quad (2)$$

But by Ohm's law, core loss is also given by

$$P = I^2R_{a-c} \text{ watts} \quad (3)$$

Equating Eq. (2) and (3) and solving for R_{a-c}, we obtain

$$R_{a-c} = kB^a w/I^2 \text{ ohms} \quad (4)$$

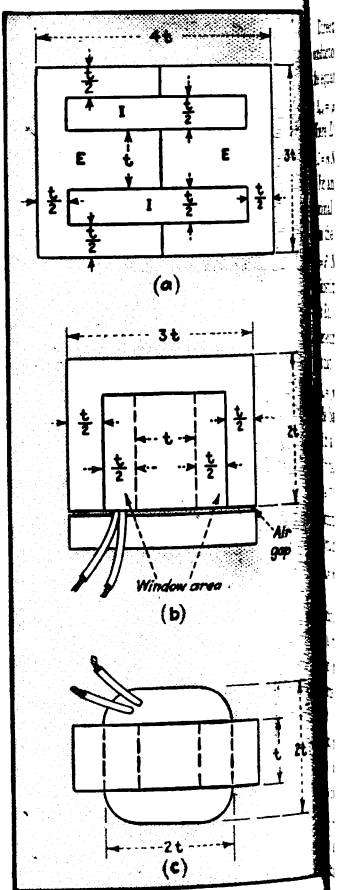

FIG. 1—(a) Layout for stamping scrapless E-I laminations. (b) Plan shows assembly of core from laminations. (c) Elevation of completed transformer, showing coil wound on core

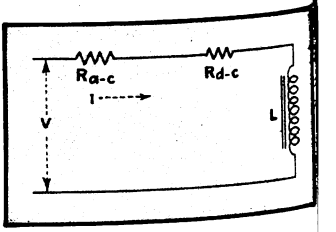

FIG. 2—Equivalent circuit of iron-cored inductor at a fixed frequency and voltage

Since the Q of the coil will usually be greater than 10, practically no error is introduced by setting

$$I = V/2\pi fL \text{ amperes} \quad (5)$$

Substituting Eq. (5) in Eq. (4) and solving, we obtain

$$R_{a-c} = 39.5kB^a w(fL/V)^2 \text{ ohms} \quad (6)$$

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Direct-current resistance of any conductor can be represented by the equation

$$R_{d-c} = \rho L'/c \text{ ohms} \quad (7)$$

Where L' can be found from

$$L' = mN \text{ inches} \quad (8)$$

For any coil the conductor cross-sectional area can be computed from the winding window area by

$$c = aF/N \text{ square inches} \quad (9)$$

Substituting Eq. (8) and (9) into Eq. (7) and solving for the direct-current coil resistance we find that

$$R_{d-c} = (mN^2/aF)0.6788 \times 10^{-6} \text{ ohms} \quad (10)$$

The basic equation for induced emf in a coil is $V = 4.44fNBA \times 10^{-8}$ volts, or

$$N = (V/4.44fBA)10^8 \text{ turns} \quad (11)$$

Substituting Eq. (11) into Eq. (10) we obtain

$$R_{d-c} = (m/aF)(V/fBA)^2 \times 3.44 \times 10^8 \text{ ohms} \quad (12)$$

Equations (6) and (12) give us the alternating-current and direct-current resistances of the inductor in terms of primary design parameters.

Inductor design is to be such that the Q will be as high as possible. Q is given by the definition

$$Q = 2\pi fL/(R_{a-c} + R_{d-c}) \quad (13)$$

It is apparent that Q will be a maximum when $(R_{a-c} + R_{d-c})$ is a minimum. Differentiating $(R_{a-c} + R_{d-c})$ with respect to B, setting the derivative equal to zero, and solving for B will give the value of B at optimum operation. Thus

$$\frac{d(R_{a-c} + R_{d-c})}{dB} = 0 =$$

$$39.5akB^{a-1}w(fL/V)^2 -$$

$$(m/aF)(V/fBA)^2B \times 6.88 \times 10^8$$

Solving this expression for B we obtain

$$B = \left[\frac{17.4mV^4 \times 10^8}{akwf^4(LA)^2aF}\right]^{1/a+2} \text{ maxwells per square inch} \quad (14)$$

Air Gap Calculations

Resistance per foot of copper wire at 20°C may be written

$$R = 2^{n/3} \times 10^{-4} \text{ ohms per foot} \quad (15)$$

Solving for wire size we find that $n = 50.79 + 10\log R$, but $R = R_{d-c}/mN$, and therefore

$$n = 50.79 + 10 \log (R_{d-c}/mN) \quad (16)$$

A well-known expression for inductance is

$$L = 3.19N^2 \times 10^{-8}(R' + l/\mu\Delta A) \quad (17)$$

In the subject case R' may be approximately expressed as $2g/A_c$, where g is the width in inches of the actual air gap between E and I pieces at the butt joint. This neglects fringing. Roters[3] has developed a method for computing air gap reluctance which takes fringing into account. By this means g may be corrected analytically. For ordinary manufacturing purposes all that is required is a general idea of gap size, and the approximate method will usually be found quite sufficient. As a matter of fact, after the coil is manufactured and assembled the gap is adjusted so that the coil inductance will be exactly the value desired.

Substituting the foregoing approximate value of R' in Eq. (17) we obtain for gap width

$$g = (N^2A_c/2L)\,3.19 \times 10^{-8} - (lA_c/2\mu\Delta A) \text{ inches} \quad (18)$$

Measured Quantities

Experimentally obtained curves for k and a for a number of magnetic materials are given in Fig. (3) and (4) respectively. These curves are obtained as follows. A sample stack of the material to be tested is obtained and a coil of any convenient size and number of turns is mounted over the core. The core is butt stacked with a gap. Inductance and Q of the test unit are measured at a number of representative voltages—enough to cover a sufficiently wide range of flux densities—for several values of frequency as parameters. (The author has used a General Radio impedance bridge with good results.)

The effective resistance as obtained from Eq. (13) is

$$R_{a-c} + R_{d-c} = 2\pi fL/Q \quad (19)$$

R_{d-c}, the direct-current resistance of the coil is easily measured. R_{a-c}, the effective alternating current of the coil can then be computed from Eq. (19) using the measured value of Q.

To determine core loss, coil current is obtained from $I = V/2\pi fL$ where V is the sinusoidal voltage measured directly across the coil after the bridge has been balanced. Obviously the input impedance of the voltmeter used for this measurement should be much greater than $2\pi fL$. Knowing the coil current, the core loss can be calculated from Eq. (3). The core should be weighed or its weight computed by counting laminations. Core loss is then

$$P_{cl} = I^2R_{a-c}/w \text{ watts per pound} \quad (20)$$

From Eq. (10) $B = (V/4.44fNA) \times 10^8$.

With this information, core loss curves can be plotted as in Fig. 5, with frequency as parameter, on log-log paper. These curves will all be nearly straight lines. The slope of these curves is the exponent a, and k can be computed for the corresponding frequency by taking the core loss at any flux density on the

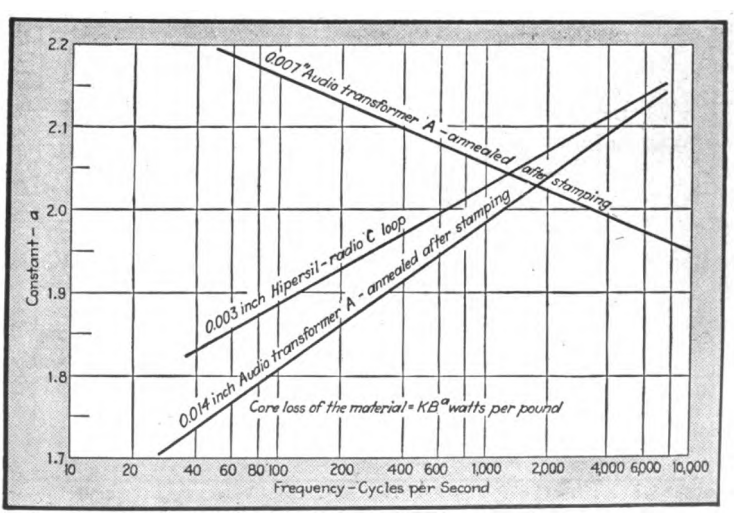

FIG. 3—Experimentally determined curves show values of a in Eq. (1) for three types of core material as a function of frequency

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curve and substituting in Eq. (1). From the data of Fig. 5 and similar curves, Fig. 3 and 4 are obtained. These curves justify the original assumption that core loss may be represented by $P = kB^a$. To complete the data necessary for designing an inductance, a typical curve of incremental permeability vs flux density is reproduced in Fig. 6, but it will be seen later that these values are not critical.

Design Procedure

A typical problem will be solved to illustrate design procedure.

Given:

- Required inductance of 5 henrys
- An available space of $2\frac{1}{4} \times 2 \times 1\frac{1}{4}$ inches
- Operating voltage of 10 volts
- An operating frequency of 1,000 cycles per second
- Core material available is Allegheny audio transformer A steel, annealed after stamping, laminations in 0.014-inch thickness (29 gage)

To find:

- Number of turns in coil
- Wire size for winding
- Lamination size and stack
- Gap width
- Q of coil

Designing for a square core cross-section, we see that a scrapless lamination with $t = \frac{3}{4}$ inch will fit the space allowed. Finished dimensions will require a space $2\frac{1}{4} \times 1\frac{7}{8} \times 1\frac{1}{2}$ inches as illustrated in Fig. 7.

First the physical design parameters will be calculated from the required conditions and the previously developed equations, and then the coil and core will be designed. Utilizing the same notation as previously, from the dimensions of Fig. 7 we obtain

$$m = 2\left(1\frac{1}{2}\right) + 2\left(\frac{3}{4}\right) = 4.5 \text{ inches}$$

$$l = 4\left(1\frac{1}{8}\right) = 4.5 \text{ inches}$$

$$w = 0.615 \text{ pounds}$$

$$A = \left(\frac{3}{4}\right)\left(\frac{3}{4}\right)(0.9) = 0.505 \text{ square inches}$$

$$A_g = \left(\frac{3}{4}\right)\left(\frac{3}{4}\right) = 0.563 \text{ square inches}$$

$$s = \left(1\frac{1}{8}\right)\left(\frac{3}{8}\right) = 0.422 \text{ square inches}$$

It will be assumed that the ratio of copper area in the window to window space area is 0.3. This is usual, somewhat less with smaller laminations, and somewhat greater with larger laminations. From Fig. (4) for 0.014-inch audio transformer A steel, annealed after stamping, k at 1000 cycles is 1.3×10^{-8}. From Fig. 3, $a = 1.987$.

From Eq. (14) B is calculated to be 89.2 maxwells per square inch. From Eq. (6) and (12), $R_{a\text{-}c}$ and $R_{d\text{-}c}$ are calculated, giving $R_{a\text{-}c} = 592$ ohms and $R_{d\text{-}c} = 600$ ohms respectively. Q is calculated from Eq. (13) using the previously determined values of resistance. This gives $Q = 26.3$.

The total number of turns is found to be 5,000 from Eq. (11), and the coil is to be wound of number 35 wire as determined from Eq. (16). Using the value of B determined previously, $\mu\Delta$ is found from Fig. 6 to be 1050. Equation (18) gives a gap length of 0.038 inches.

It should be noted that the value of $\mu\Delta$ need not be accurate for even if it varies by 100 percent, the gap is barely affected.

The coil is designed to fit a window length of $1\frac{1}{8}$ inches with $\frac{1}{8}$ inch on each side for a margin. Usable winding length is then $\frac{7}{8}$ inch. The nominal diameter of number 35 wire is 0.0061 inch, and thus turns per layer $= (\frac{7}{8})/0.0061 = 143.5$ turns. Allowing 5 percent for irregularities, we can expect the turns

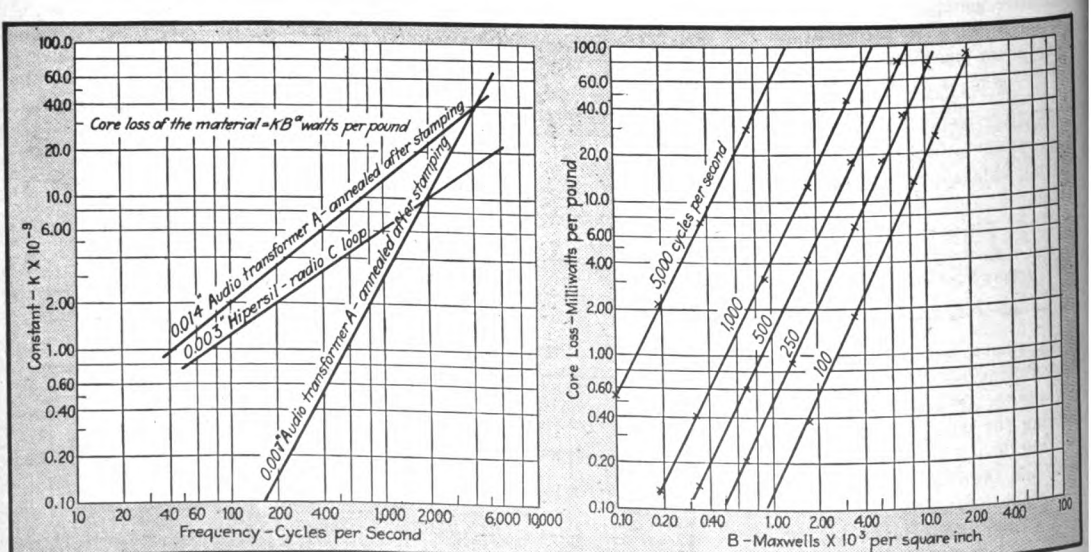

FIG. 4—For use in determining core loss in inductor calculations, k as determined experimentally for three different materials is given here as a function of frequency

FIG. 5—Core loss measured at several frequencies for a small sample of 0.007-inch high-silicon steel, Allegheny audio transformer A, annealed after stamping

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per layer to be (0.95) (143.5) = 136 turns. From previous calculation we found that 5,000 turns were required, therefore the number of layers will be 5000/136 = 37 layers.

It should be noted that R_{a-c} and R_{d-c} come out nearly equal. This will verify the rule followed by most designers that for optimum Q the fixed losses represented by R_{d-c} should be equal to the variable losses represented by R_{a-c}. If in Eq. (14) a is set equal to 2, the same result is obtained as when Eq. (6) and (12) are equated and solved for B. In other words, the rule is accurate if $a = 2$. Actually, a is usually nearly 2.

The coil as designed above was constructed and with the gap adjusted to give $L = 5$ henrys at 1,000 cycles and 10 volts, Q was found to be 25.9, which represents an error of 1.5 percent. The gap was actually found to have been adjusted to be about 0.060 inch as against about 0.04 inch computed. This discrepancy is due to fringing.

Effect of Varying Inductor Parameters

Suppose that it is desired to reduce the size of the inductor by using a ½-inch scrapless E-I lamination with a ½-inch stack. What is the effect of this change in physical constants on the characteristics of the coil if the inductance is to remain 5 henrys at 10 volts and 1,000 cycles? Taking $F = 0.25$ we find that

B = 209 maxwells per square inch
R_{d-c} = 994 ohms
R_{a-c} = 935 ohms
Q = 16.3
N = 4,790 turns
n = No. 39

This is obviously not as good as the first coil because the Q is lower and number 39 wire is harder to handle.

Suppose the same ½-inch lamination is used but with a one-inch stack, what then? The results are

B = 135 maxwells per square inch
R_{d-c} = 796 ohms
R_{a-c} = 800 ohms
Q = 19.7
N = 3,710 turns
n = No. 38

This coil is better than that obtained with a ½-inch stack but not so good as that obtained with the ½-inch lamination.

Following this lead, suppose the coil is redesigned to use a 1-inch scrapless lamination, with a one-inch stack. Taking $F = 0.35$,

B = 48.5 maxwells per square inch
R_{d-c} = 413 ohms
R_{a-c} = 415 ohms
Q = 38
N = 5,180 turns
n = No. 32

If a Q of 26 is not high enough for the first case that was computed and more space is not available, will using an 0.007-inch lamination thickness in the same size lamination, i.e., ¾-inch scrapless, improve the coil? New values of a and k are found from the graphs. The results are

B = 117.5 maxwells per square inch
R_{d-c} = 362 ohms
R_{a-c} = 312 ohms
Q = 46.6
N = 3,880 turns
n = No. 34

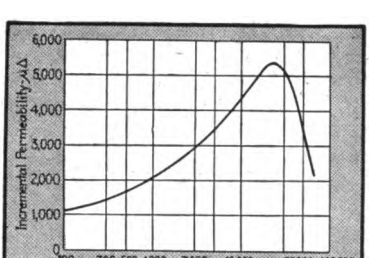

FIG. 6—Incremental permeability characteristic of 0.014-inch Allegheny audio transformer A core steel

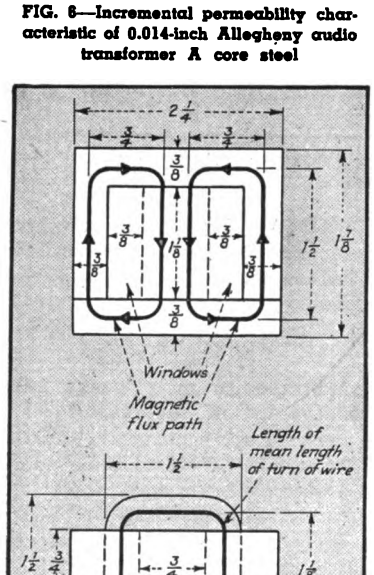

FIG. 7—Dimensions of inductor calculated by method developed in text

As might have been expected, a thinner lamination will improve the Q.

Taking the original coil, 5,000 turns of number 35 wire on a ¾-inch E-I, ¾-inch stack, Allegheny audio transformer A steel, annealed after stamping, 0.014 inch thick, operated at 10 volts, what happens if the frequency is changed to 500 cycles? Results are

B = 226 maxwells per square inch
R_{d-c} = 600 ohms
R_{a-c} = 385 ohms
Q = 15.95
L = 5.02 henrys

If the frequency is maintained at 1,000 cycles, but voltage is increased to 20 volts, what is the effect?

B = 178 maxwells per square inch
R_{d-c} = 600 ohms
R_{a-c} = 586 ohms
Q = 26.5
L = 5.01 henrys

It should be noted that due to the large air gap, the inductance remained practically independent of voltage and frequency.

Thus the basic design equations may be used and applied to almost any magnetic material, regardless of shape or size, and the effects of various parameters may be easily computed.

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HARMONIC SUPPRESSION for Aircraft Generators

Consideration of effects of wave-form distortion in 400-cycle and other high-frequency aircraft and marine generators, and procedure for designing a series-resonant filter to reduce harmonic content. The third harmonic requires maximum suppression

THE need of a frequency-discriminatory network capable of passing power and suppressing harmonics from an alternating source has grown with the expansion of the electric power field into frequencies higher than 60 cycles. For instance, the popularity of 400-cycle power for aircraft and small marine craft has called for the use of small generators which often have poor wave form characteristics.

In small high-frequency generators (400 to 2600 cycles) the wave form distortion may reach 30 percent. If electrical measurements are to have much significance and be subject to duplication later, they must be based on a known wave form, preferably a sine wave. This paper will discuss the design and characteristics of one type of band-pass power filter that has proved highly successful in correcting wave form at these frequencies.

Power filters generally require the suppression of multiples of the fundamental frequency. The only circuit available which will produce a band-pass effect without shunt arms appears to be a series resonant circuit, as shown in Fig. 1(a). The generator resistance is assumed to be negligible in comparison with the load resistance. The insertion loss of the circuit at the pass frequency is given by

$$\text{db loss} = 20 \log \left(1 + \frac{X_L}{QR}\right) \qquad (1)$$

where R is the resistance of the load and Q and X_L apply to the filter. The loss at any other frequency, assuming that the resistance of the filter coil is negligible in comparison to the load resistance, is

$$\text{db loss} = 10 \log \left[1 + \frac{(X_L - X_C)^2}{R^2}\right] \qquad (2)$$

In the design of power filters, knowledge of the magnitudes of the harmonic components to be suppressed is of considerable aid. If a sketch of the wave form to be corrected is available, a Fourier analysis will give the magnitude of the harmonics. Such an analysis was made of the output voltage of a 2-kva, 500-cps generator, giving

$$e = \sin x - 0.22 \sin (3x - 25.7°) - 0.118 \sin (5x - 54°) + 0.05 \sin (7x + 36.9°) + 0.033 \sin 9x - 0.02 \sin (11x - 19.3°) + \ldots\ldots$$

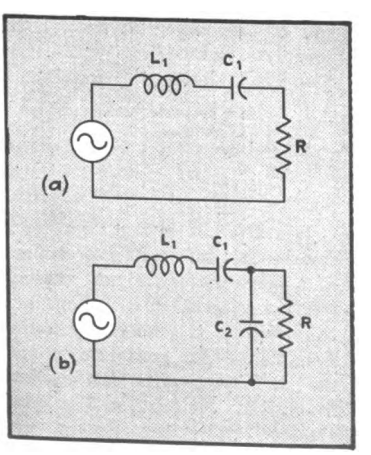

FIG. 1—(a) Series resonant filter and (b) use of a capacitor across the load with the same filter for additional suppression of higher harmonics

where $x = \omega f = 2\pi \times 500$ and phase-shift angles are given in terms of their respective harmonics. The analysis was made through the 11th component. The total harmonic content through the 11th was 26 percent. A graphical analysis of this wave is given in Fig. 2.

Filter Design Procedure

Let us say that the harmonic content of the above-analyzed wave is to be reduced from 26 percent to 5 percent. To reduce the amplitude of the 3rd harmonic from 22 percent to 5 percent of the fundamental amplitude would require a db reduction of 20 log (e_a/0.05) or 20 log (0.22/0.05), which is 12.9 db at 1500 cycles.

But since there are more harmonics than the 3rd to be suppressed, a greater loss of the 3rd than 12.9 db is required. With a 15-db loss at 1500 cycles, the 3rd is reduced from 22 percent to 3.9 percent, the 5th is down to 20 db or reduced from 11.8 percent to approximately 1.2 percent, and the effective sum of the 7th, the 9th, and the 11th is less than 1 percent. The summation of the harmonics is

$$\sqrt{E_3^2 + E_5^2 + E_7^2 + E_9^2 + E_{11}^2} = \sqrt{3.9^2 + 1.2^2 + 1^2 + \ldots\ldots} = 4.2\%$$

Therefore, this design would suffice. If neglect of the higher harmonics causes greater than 5 percent distortion, a correction may be applied by shunting a capacitor across the output as in Fig. 1(b). This is permissible if the capacitor has a high impedance at the pass frequency. Since the capacitor cur-

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By F. W. JAKSHA

Thordarson Electric Mfg. Co.
Chicago, Illinois

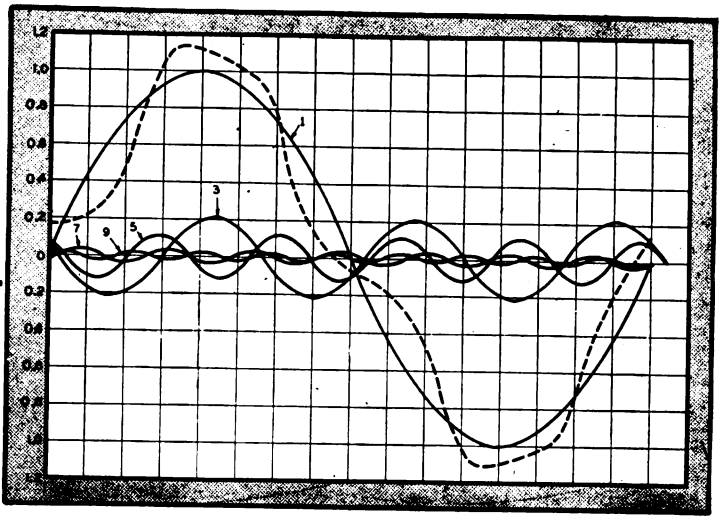

FIG. 2—Graphical analysis of the output voltage of a 2-kva, 500-cps generator. Harmonics are identified by number; the dash-dash curve represents the distorted output wave form. The 11th and higher harmonics are not shown

rent is at quadrature with the load current it may be as high as 32 percent of the load current and cause only a 10-percent increase in the generator current.

The addition of a shunting capacitor will cause the resonant frequency of the unit to increase as the load is lessened. The output voltage at the resonant frequency will then be greater than the generator voltage, but the voltage output at the desired pass frequency will still be the same as the fundamental of the generator.

A good test of the filter is to take two voltmeters whose operation is based on two different systems of measurements, such as an rms voltmeter and a peak-reading type. At the output of the generator they will read differently, but at the output of the filter they should read the same if filtering is effective.

Determination of Circuit Constants

For a 2-kva, 500-cps, 220-volt unit, the rated current would be 9.1 amperes. The resistance at maximum load would be 220/9.1 = 24.2 ohms. Assuming that the aforementioned 15-db reduction at 1,500 cycles would be satisfactory, the determination of X_L and X_c follows directly from Eq. (2):

$$15 = 10 \log \left[1 + \frac{(X_L - X_c)^2}{R^2} \right]$$

$$= 10 \log \left[1 + \frac{(X_L - X_c)^2}{24.2^2} \right]$$

At 1,500 cps, $X_L - X_c = \sqrt{24.2^2 \times 31.6} = 136$ ohms

At 500 cps, $X_L - X_c = 0$ ohms

Solving the last two equations, L equals 16.25 mh and C equals 6.25 μf. At full load, the rms voltage of the fundamental across either L or C is $9.1 \times 0.01625 \times 6.28 \times 500 = 465$ volts. Harmonic voltages may either increase or decrease the corresponding peak voltage of $1\,414 \times 465 = 658$ volts.

Assuming that a loss of 5 percent in output is permissible, the coil resistance could be $0.05 \times 2000/9.1^2 = 1.2$ ohms. This resistance means a dissipation of 100 watts in the filter unit, which would be difficult to obtain without excessive heat rise. A dissipation of 50 watts should be more feasible, thereby requiring a reduction of the coil resistance to 0.6 ohms. Thus, the insertion loss is inherently low since the Q of the circuit is governed by heat rise in the unit and not by the permissible insertion loss.

In tests made with a power filter unit for a 220-volt, 1-kva, 500-cps generator, there was a slight distortion at full load amounting to about 5 percent as viewed on an oscilloscope. As the load was decreased, the distortion disappeared. Under no-load conditions there was no apparent distortion. A test was also made with the primary of an open-circuited transformer as a load. Again there was no apparent wave-form distortion. With an inductive load the resonant frequency of the system is lowered, but this does not affect the output voltage at the pass frequency.

Use of Air-Core Coils

The inductance values required for power filters often permit a choice between air and iron-core coils. In making a decision, a number of disadvantages of iron-cored units must be taken into consideration: (1) the exciting current of iron-core coils introduces additional distortion; (2) with iron cores, only a few turns are needed. This results in high voltages between adjacent turns and between layers, creating difficult insulating problems. The small number of turns also makes accurate design and adjustment of the coils difficult; (3) a large iron core is needed to give a satisfactory Q and prevent magnetic saturation, and this can make the inductance too large. For these reasons, air-core coils are generally used.

The addition of a band-pass power filter to a generator producing relatively high harmonic content offers several advantages. For example, use of a filter changed the rms-peak ratio from 0.75 for the uncorrected wave to the sine-wave value of 0.707, and changed the average-peak ratio from 0.53 to the 0.636 value for a sine wave. With this wave-form correction, all types of meters calibrated on a sine-wave basis will read accurately.

Wave-form correction usually reduces peak voltages, lessening chances for voltage breakdown of connected electrical components.

Manufacturers will find that motors and transformers that just exceed heat rise limits when tested with voltages containing high harmonics may pass when the wave form is corrected, due to reduction of high-frequency iron losses.

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STUDIO AND CONTROL-ROOM DESIGN

Program-handling equipment for student-operated college-campus broadcast system is simple and fool-proof. Studio can be adapted to production of a wide variety of programs. Control room is versatile yet simple enough for one-man operation

By WILLIAM REAGH HUTCHINS
Columbia University
New York

STUDENT INTEREST in all phases of broadcast program production from script writing to on-the-air station operation has given rise to over seventeen college or university campus stations. Although details of each network differ, the most usual method of distribution is wired wireless because of its controlled coverage—usually only the student dormitories—and absence of licensing requirements.

In normal times about 90 percent of the college students have radios in their rooms. Many of them prefer local campus talent; so the listening audiences on the college station's frequency are large. Campus originated programs include campus and world news and sports, interview and discussion programs, debates, comedy, dramatics, and a large proportion of both classical and popular recorded music, with a few live music programs.

Campus studio and program equipment designed to handle such a variety of material is at least as intricate as that of standard broadcast stations, especially since space and cost limitations are usually more stringent.

Studio Design

Special considerations involved in the design of college studio equipment are as follows:

COST: Budgets are usually very limited because most of these networks are run and financed by students with the aid of small subsidies and some advertising.

SIMPLICITY OF OPERATION: Equipment is invariably operated by personnel with little or no previous radio experience. Smoothness and quality of programs must nevertheless be as good as that of the majority of broadcast stations in order to hold an audience.

SIMPLICITY OF MAINTENANCE: The minimum of care must be required, and trick circuits must be avoided because the maintenance staff frequently may be little better trained than the operators. Sometimes emergency repairs must be made by members of the program department who have absorbed little technical knowledge by contact with the engineering staff.

FLEXIBILITY: Usually only one studio is available for all types of programs. This means that rapid changes in setup, mike placement and personnel must take place between programs with no hitch in the smoothness of the material going out over the air. Dramatic shows must be as easy to handle as other programs. Yet too much flexibility causes a loss of simplicity; so a compromise must be reached.

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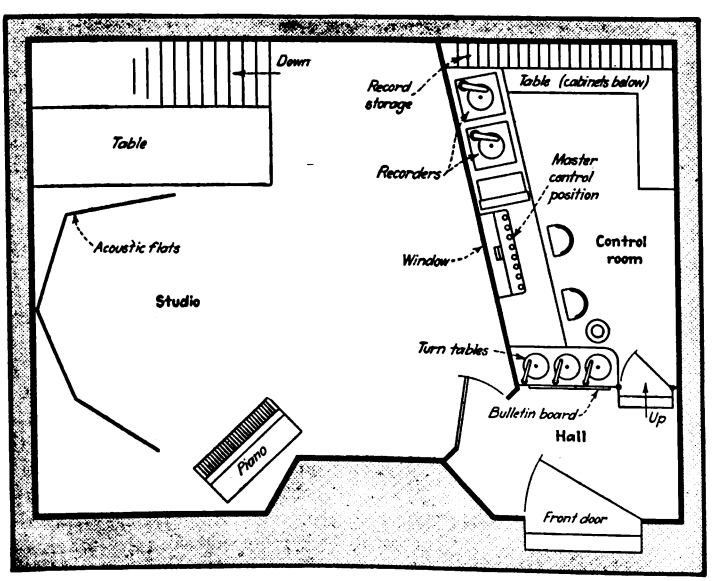

FIG. 1—Studio walls are placed at irregular angles to minimize acoustic standing waves; control room is laid out to minimize personnel required for complete station operation

Station Layout

The entire space made available for construction of broadcasting fa-

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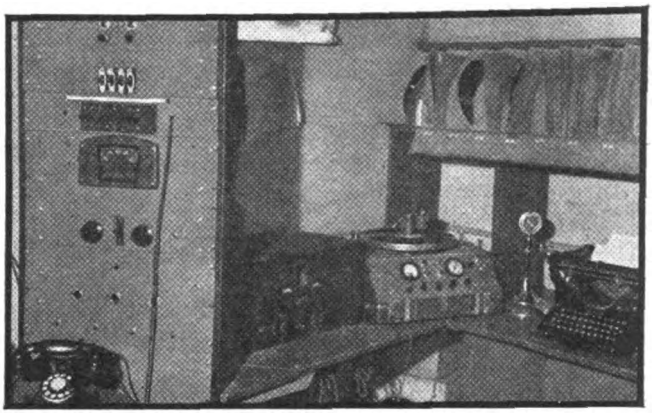
graph position at left has its own mixing controls. Main at right commands view of studio. Students plan and produce all programs



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Until recently, heavy carpet laid on rug cushion, and Insulite and thin Fibreboard on the control-room wall constituted the only permanent absorbing medium in the room. Acoustic flats, or goboes, consisting of two inches of Rockwool fastened to plywood backing, covered with thin cloth and fitted with braces so they can be moved about the floor, are depended on for acoustic treatment of the sides of the microphone area. The goboes used here are four feet by eight feet, but have proved rather unwieldy; smaller ones would be better.

Control room layout depends largely on the personnel which is expected to be used in regular and emergency operation. At CURC (Columbia University Radio Club) a station manager, announcer, monitor, and turntable operator are normally on duty. In the case of dramatic programs, the director replaces the station manager.

The console is placed under the right end of the window, with equipment racks within easy reach at the monitor's right. At his left sits the station manager or director, with the turntable operator to the left of him. Because the equipment is bent into a broad U, it is possible in an emergency for one person to run the station.

Recording equipment is at the rear of the racks, thus putting it out of the way, and at the same time accessible to all circuits. The remainder of the control room is devoted to record storage, workbenches and cabinets.

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With the high turnover and inexperience of the staff, station operation must be easily learned. A switch or dial must materially increase the utility of the apparatus before it is included. This test rejected many gadgets before the final design of CURC was completed. If auxiliary gadgets are found desirable, they should be put on a panel away from the main console where their presence will not confuse inexperienced operators.

The main console of CURC includes six complete input channels and two output channels as shown in Fig. 2. The only controls on the panel are associated with these circuits or the monitoring of them.

Two output amplifiers of identical design are terminated in 500-ohm *unbalanced* transformers with attached load resistors. Across these loads may be connected almost any number of high impedance circuits, such as bridging grids. Bridging transformers and their ills are thus eliminated.

Each outgoing balanced transmitter audio line is fed by a low-gain bridging amplifier, the input grid of which may be switched to either of these program bus circuits. Monitor and cue amplifiers, VU meter, and recorders may similarly be tied to these busses.

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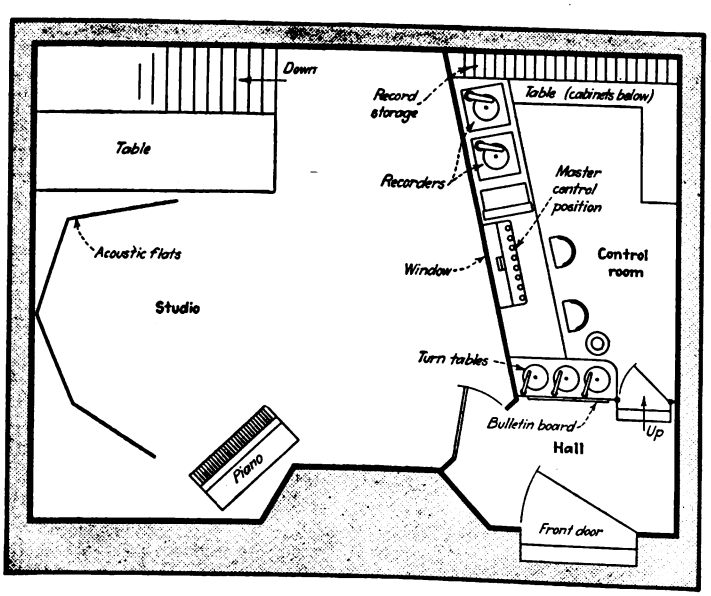

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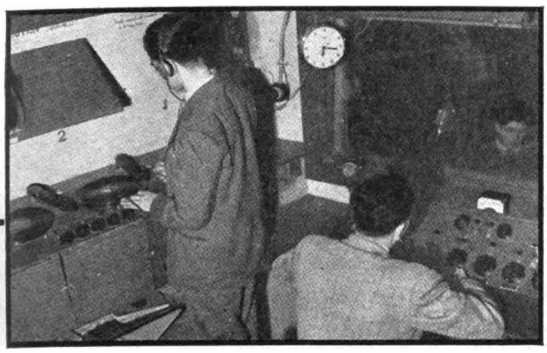
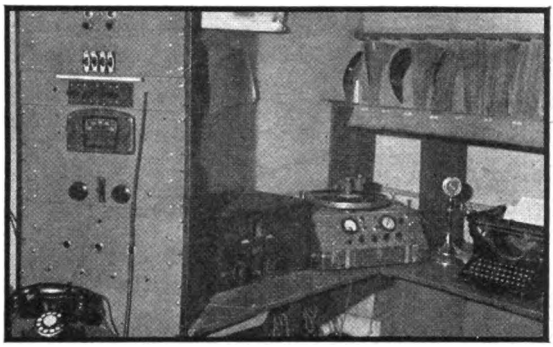


Phonograph position at left has its own mixing controls. Main console at right commands view of studio. Students plan and produce all programs



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cilities at Columbia University was a room 19 feet by 27 feet overall, but having several jogs in the walls and a stairway which had to be left untouched. Into this room had to be crowded studio, control room and office facilities for the station. The layout finally used is shown in Fig. 1.

Any station requires three space areas: the *studio* itself, the *control room*, and a *hallway* from which these may be entered and which acts as a sound-lock to prevent feedback. The floor of the control room should be raised at least ten inches above that of the studio so that vision is unobstructed by performers standing or sitting in front of the control room window, and so that persons seated in the control room are at the eye level of those standing about microphones in the studio.

It is extremely important that everyone involved in the program be able to see everyone else. As large as possible a soundproof window between studio and control room is therefore essential. The size of this window is only limited by cost. By careful placement and layout it was possible at Columbia to keep the glass area down to two feet by four feet.

Studio and Control Room

Studio layout and shape should be determined chiefly by acoustic considerations. Here, however, maximum utilization of the available area had to take precedence. Since proper acoustic treatment of all wall areas was out of the question financially, the walls which were added were set at odd angles to prevent repeated sound reflections and thus reduce the possibility of distinct standing waves in the room.

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High-impedance potentiometer gain controls and electronic mixing circuits are employed. This arrangement eliminates costly and bulky mixing transformers which

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can be a source of hum and distortion. Thus simple switching circuits and standard receiver-type volume controls can be used. Controls of the type having a metal contact-band have been in use for over two years with *no* maintenance or noise.

Loss of high-frequency response when controls are turned down is prevented by using relatively low impedance potentiometers and pentode mixer tubes to reduce shunt capacitance. Since each input circuit may be connected to either output channel or turned off by the channel switches, care must be taken that switching-in of additional channels causes no clicks, changes of level or frequency response. Clicks are prevented by the use of high resistances on the switch sides of all coupling capacitors, while level changes are reduced to ½ db per switch by use of 10,000 ohm master gain controls on the output amplifiers.

Master Control Position

Starting at the left of the panel, the input circuits of the main console are:

CONTROL-ROOM MICROPHONE: Also used for studio talk-back when the studio mikes are dead.

PHONOGRAPH INPUT: Brought from four-position mixer on turntable panel.

TWO STUDIO MICROPHONES: 50 ohms is used for standard program-microphone impedance. (Inputs in the console include transformers and preamplifiers. Low impedance allows the use of almost all types of ribbon, dynamic and cardioid microphones interchangeably. It also permits unshielded twisted-pair to be used for emergency microphone cable extensions. As much as a half mile of twisted pair has been used in this manner without bringing hum and noise level up far enough to damage intelligibility.)

SPECIAL EFFECTS: Intended to be fed subsequently from a filter and echo-chamber control panel to be mounted in a rack. (This position is now connected through a simple high-pass filter stage to the output of the second studio microphone channel preamplifier. The telephone effect thus produced is satisfactory for a large proportion of dramatic work.)

GENERAL UTILITY: The only channel with an input selector switch, the utility input may be connected to an extra output of the phono mixer, to an f-m translator, or to the output of the remote line switching panel. When another studio is added, one of these sources may be replaced by the second studio.

Each mixer gain control has immediately above it the switch which connects it to either output amplifier, or turns it off. The down position of all switches in the station is that normally used when the circuit controlled by that switch is on the air. This proves a great aid to the memory. The off position is in the middle where practicable.

Interlocked Switching

There is only one switch above each control, and each does the same thing; so there is no chance for ambiguity. The talk-back switch is located by itself at one end of the panel (that near the director), and the utility channel selector is at the other end.

The master gain controls are located at the extreme right, while all monitor controls, as well as the studio cue fader are placed at the top of the panel, immediately under the VU meter. The meter projects up into the line of vision, and is illuminated from below.

A separate talk-back power amplifier to feed a speaker in the studio is included in the console. When the studio mikes are not on the air, the input of this amplifier may be fed through a cue fader from either the output of the program channel or from the off positions of the phono and utility channel switches. Operation of the talk-back key automatically disengages these inputs and connects the control-room microphone.

Figure 3 shows how all switches in the console are interlocked, either directly or through relays so that feedback is impossible. The same relays which disconnect the speak-

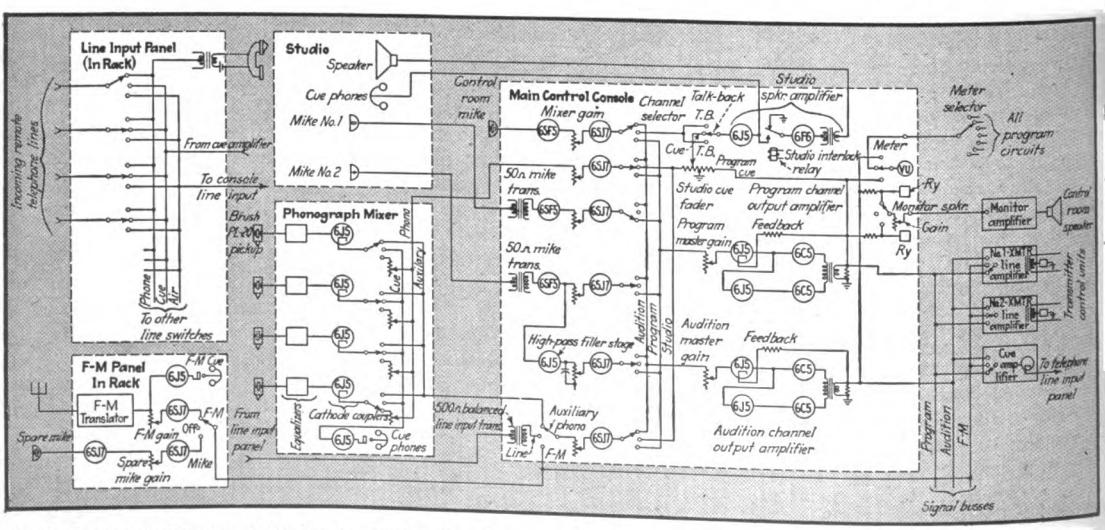

FIG. 2—Single-line diagram of circuits showing location of equipment and type of signal switching used in routing channels through control room

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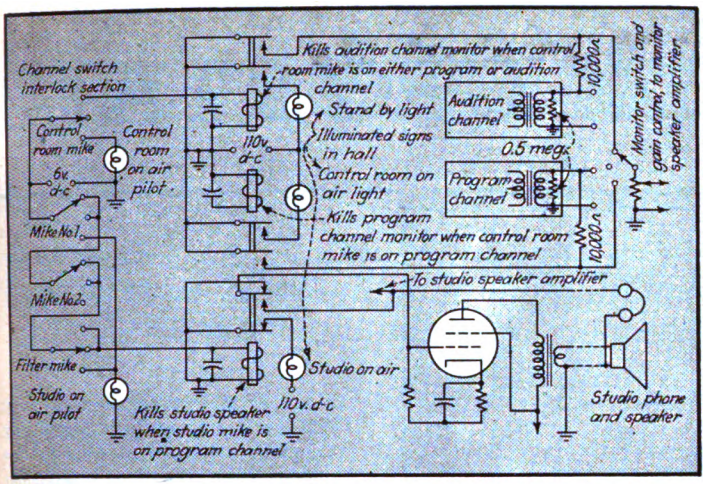

FIG. 3—Associated with console signal-channel controls are interlock relays for operation of hall and pilot lights and studio loudspeaker

ers also are used for stand-by and studio on-the-air lights. When studio microphones are connected to the program channel, the studio loudspeaker is killed; but if connected to the audition channel, the studio speaker may be used with the microphones on because, in this case, the talk-back switch cuts off the control-room speaker. Not only is time saved in rehearsals but this connection permits stunts by feeding the output of the audition channel to the transmitters.

Relays are operated by microphone channel switches. When the microphone is off, the relay is energized. Thus the instant the switch starts to operate, the relay coil is opened, and by the time the microphone is connected the relay has shorted the loudspeaker circuit. Freedom from feedback and clicks is thereby assured.

Phonograph Equipment

There are three turntables in regular use. Two of these are synchronous at 78 rpm. The third is a dual-speed rim-driven table normally used at 33⅓ rpm. Inasmuch as the phonograph operator usually stands up, all three turntables are mounted at a 36-inch height. Turntables are located in the control-room to make integrated direction of the large proportion of programs more simple.

Each turntable is equipped with a 16 inch high-quality, low-pressure crystal pickup, and in addition one of the 78 rpm tables is equipped with another pickup to facilitate continuous running of sound effects. All four of these pickups are connected through equalizers to a mixing panel at the front of the phono console.

The output of each equalizer goes through a cathode-coupled stage to a key-switch and volume control. In the off or center position of these switches the outputs of the pickups are connected to a headphone amplifier for cueing purposes. Only in the down or air positions are the volume controls connected. The up positions of the switches go to one of the positions of the utility channel switch in the main console.

Remote Program Equipment

Single twisted-pair telephone lines run from the studio to most buildings on the campus. These lines terminate at the station in key switches on a phone panel in the rack at the operator's right. In the middle or off positions of these switches cue is fed over all lines. The up positions connect to a telephone handset. When a switch is thrown down it is connected to one of the positions of the utility channel selector switch in the console.

A small battery-operated remote amplifier is used in most cases to feed program over the lines. This amplifier is equipped with a two-position electronic mixer, master gain control, and db meter. One of the microphones and the monitor headphones are used for telephone communication with the handset in the control room. This is simple and adequate and cuts to a minimum the amount of equipment which must be taken on a remote.

A more elaborate, a-c operated remote amplifier with a built-in public address system has recently been built to meet the needs of elaborate audience-participation shows.

News, public events, and a certain amount of music are rebroadcast from local f-m stations. A standard f-m translator is mounted in the rack at the operator's right with cue and switch circuits. On this panel there is also a separate high-impedance microphone input

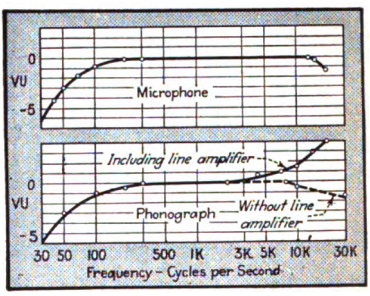

FIG. 4—Response of audio system

with amplifier and gain control.

The f-m panel may be fed directly to the transmitter line amplifiers, thus by-passing the main console when only f-m and announcements are to be broadcast for a long period. The output of the panel may also be connected to one position of the utility channel selector switch. The microphone input on the f-m panel may be used to give an extra studio microphone channel for elaborate shows.

Performance Characteristics

Due to use of inverse feedback, a minimum of transformers, and careful design, frequency response is within 1½ db from 60 to 20,000 cycles for all channels from transducer to console output. Distortion is much less than one percent at all frequencies from 50 to 7500 cycles at levels up to 20 db above normal full output. Hum and noise are better than 40 db down from zero level. Although no pains were taken to reduce them still further, greater reduction should be fairly simple were it necessary. Typical frequency response curves are shown in Fig. 4.

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QUARTZ CRYSTAL

By C. W. FRANKLIN
Cambridge Thermionic Corporation
Cambridge, Mass.

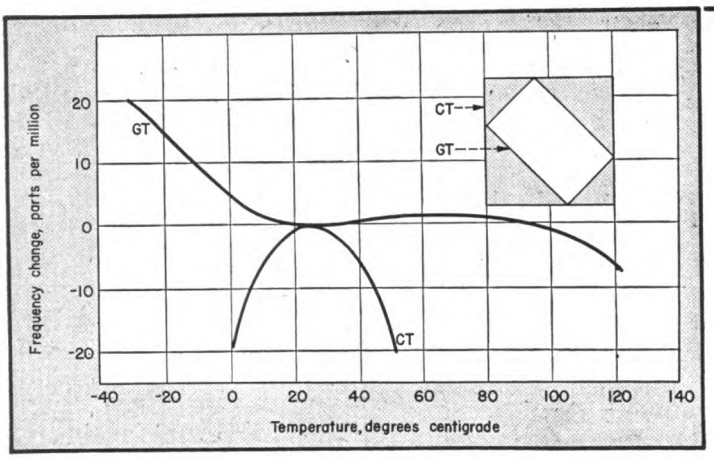

FIG. 1—Comparison of the temperature-frequency characteristics of the CT and GT cuts. The insert shows the angle of cut of each

JUST WHAT is a good crystal? Obviously, it must have certain qualifications; it must possess a clean-cut frequency spectrum of its own, free from secondary frequency interference, and free from drift or the tendency to jump under conditions normal to its operation.

Originally most crystals were good crystals. The demands made upon them were no more stringent than those made upon the tubes and circuits of the period. With heat regulation, an X-cut or Y-cut crystal gave greater stability than a heat-regulated tube circuit. To be sure, both these cuts had troublesome secondary frequencies, but with sufficiently patient workmanship these secondary frequencies could be controlled.

Crystals were used long before the war as frequency standards and in narrow band filters. Because of their wide usefulness, and in proportion as the qualifications of circuits themselves improved, the demands made upon crystals steadily increased. For instance, the X-cut crystal had a temperature drift of −20 to −50 parts per million per degree centigrade, and the *Y*-cut had a drift of +60 to +100 parts per million per degree centigrade. The thinner the crystal, the worse the drift in each instance. Such drift ceased to be acceptable.

Effect of Angle of Cut

Mathematical analysis in terms of the elastic constants of quartz and the angle of cut was called in to provide crystals which would be good in terms of more exacting requirements. It was found that there were certain angles through which a Y-cut might be rotated about its X-side in cutting from the quartz, for which a minimum of coupling between the desired thickness-frequency and conflicting modes existed. Further, an analysis showed that close by were two other angles of cut which yielded zero drift in the neighborhood of a fixed temperature. It was, therefore, assumed and verified experimentally that crystals cut at either of these latter angles would be desirable both for their zero drift and the relative purity of their vibratory mode. Thus the AT and BT crystals were arrived at.

These were highly desirable cuts. So long as a relatively small band about their points of zero temperature drift was satisfactory, they left little to be wished for in their frequency class. However, outside of this band, they had a small but by no means negligible drift increasing parabolically on either side. They were, moreover, limited as to range by the fact that they were thickness vibrators, since it was not practicable to make them too thick or too thin.

To serve the low-frequency range, the CT and DT crystal plates, cut at about 90 deg from the BT and AT respectively, and vibrating in face sheer, were devised. These, too, had zero drift at preassigned temperatures and were parabolic in drift elsewhere. Because their faces governed their motion, they had to be center-mounted and were, therefore, more difficult than the preceding crystals to handle. But they filled in the frequency range for zero-drift crystals down as far as 70 kilocycles.

The GT Type

There was still, however, no crystal having zero drift over an extended range. As a result of adroit mathematical and physical reasoning, a crystal, cut at a 45 deg angle from CT blanks and thereafter very carefully dimensioned, was conceived, and had a drift of only one part in a million over a range of 100 deg centigrade. Its frequency range is from 60 to 1000 kc, approximately. This is the remarkable GT crystal. Its temperature coefficient is illustrated in Fig. 1 and compared with that of a CT blank.

Finally, in the very low-frequency range, there are the MT longitudinally vibrating crystal (which may be given zero temperature coefficient for certain length-width ratios), and the NT which vibrates

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IMPROVEMENTS

War-time need of better quartz crystals by the millions has caused manufacturing tech niques to advance under forced draft. Such engineering progress, if encouraged by larg demand in peacetime, may lead to still better crystals

in flexure at frequencies as low as 4 kilocycles. The latter approximates zero temperature coefficient in certain ranges.

The current crystal repertory is given in the table. Step by step, the demands have gone up, as step by step the conditions normal to operation have become more extended.

Future Improvement

How much further can this process go? How much better is the good crystal likely to become?

Mathematically the field has steadily narrowed. Anything as interesting as the GT cut (and comparatively as easy to cut) is not likely to occur again, though it is rash to say that there will not be improvements.

From now on the largest field for improvement must lie in the processes of manufacture. Careless tolerances must be eliminated so that the final product is in all cases true to the designer's original intent. And finally, much more systematic attention must be paid to the question of correct dimensions.

The GT crystal was produced from the CT by a trick of orientation and a very exact apportionment of dimensions. Yet, in general, with such crystals as the AT and BT, such dimensioning as is done is left to the manipulative skill of the crystal finisher. It is still often a matter of art rather than science. Yet a scientific approach to the problem is possible. Advantageous dimension ratios show an amazingly consistent pattern from crystal to crystal and from frequency to frequency. Such knowledge must be codified and made available. Data of the type given in ELECTRONICS, p. 112, June 1945 is a step in this direction. Thus, as the purely mathematical field of exploration narrows, this important and neglected field of research lies open.

From the beginning, crystals have had a unique role to play in electronics. Wartime need has required crystals to serve from the stratosphere to the equator, from desert aridity to the supersatu tion of the tropics, and their d signers have risen to these d mands and met them. The po war world will require them to b come still better. Crystal researc working hand-in-hand with man facturing skill, must produce t good crystal of the future.

LOW-TEMPERATURE COEFFICIENT CRYSTAL CUTS

Plates

Cut	Mounting	Frequency in kc	Temperature Coefficient	Range in kc for practicable size	Use
AT thickness shear	Corner clamped or beveled edges	1660 per mm thickness	Zero at temperature controlled by z'-angle	500....4500 (30,000 if odd harmonics used)	Oscillators
BT thickness shear		2500 per mm thickness	Zero at temperature controlled by z'-angle	2000....20,000 (fundamental)	Oscillators
CT face shear	Center-mounted	3100 per mm length	Zero at temperature controlled by z'-angle	100....500	Oscillators, filters
DT face shear	Center-mounted	2100 per mm length	Zero at temperature controlled by z'-angle	70.....400	Oscillators, filters
ET face shear and 2nd flexure	Center-mounted	5350 per mm length	Zero at temperature controlled by z'-angle	200..1000	Oscillators (little used)
FT face shear and 2nd flexure	Center-mounted	4700 per mm length	Zero at temperature controlled by z'-angle	140....800	Oscillators (little used)
GT extension	Center-mounted with knife edges on nodal line	3292 per mm width	Zero over 30-deg interval controlled by z'-angle; changes only 2 parts per million over 100 deg C	60....1000	Frequency time standard
			Bar Type		
Thin 5 deg X-bar extension length	Center-mounted	280 per cm length	Zero to correct temperature	50.....500	Moderate stability medium width filter
—18.5 deg X-bar extension length	Center-mounted	300 per cm length	25 parts per million	50.....500	Band-selecting filters
MT	Center-mounted	275 per cm length	Zero over a moderate range about correct temperature	50.....500	Pilot chan. filters, osc.
NT flexure	Double-plated to vibrate in flexure and mounted at two nodal points	180 per cm down according to exact angles and dimensions	Nearly zero at proper temperature	4.....50	F-M trans. pilot-chan. filters of carrier cable

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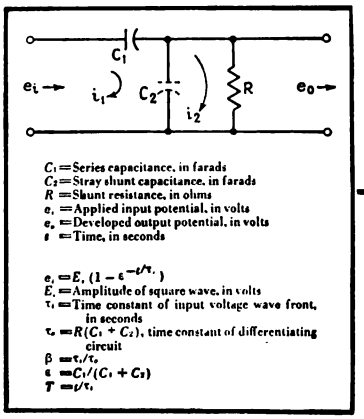
Square-Wave



C_1 = Series capacitance, in farads
C_2 = Stray shunt capacitance, in farads
R = Shunt resistance, in ohms
e_i = Applied input potential, in volts
e_o = Developed output potential, in volts
t = Time, in seconds

$e_i = E_i(1 - \epsilon^{-t/\tau_i})$
E_i = Amplitude of square wave, in volts
τ_i = Time constant of input voltage wave front, in seconds
$\tau_o = R(C_1 + C_2)$, time constant of differentiating circuit
$\beta = \tau_i/\tau_o$
$\epsilon = C_1/(C_1 + C_2)$
$T = t/\tau_i$

TABLE I—Differentiating circuit and definitions of terms discussed in text

From analytical treatment of pulse-generating circuit, generalized circuit design charts are plotted giving pulse amplitude and length. Time constant of the input wave front and stray shunt capacitance of the differentiating circuit are considered

IN THIS PAPER the response of a conventional *R-C* differentiating circuit to a square-wave voltage having an exponential rise is to be analyzed. Formulas will be derived and curves given which apply to both analysis and design of this type of differentiating circuit. In particular, these formulas and curves enable one to calculate the shape, length and magnitude of the output-pulse voltage of the differentiating circuit.

Electrical Considerations

Upon sharply differentiating a square-wave voltage it is common experience to find that the magnitude of the output-pulse voltage is only a small fraction of the magnitude of the input. This loss in magnitude is due principally to two things. Firstly, the square wave is never truly square but has a front of finite slope (usually closely exponential in form); secondly, there is always associated with the resistance of the differentiating circuit some stray shunting capacitance which brings about a division of the input voltage between this stray capacitance and the series capacitance of the differentiating circuit.

Intuitively one can see that the more closely the voltage wave approaches a true square wave and the smaller is the stray capacitance, the greater will be the output of the differentiating circuit. However, it is difficult to say beforehand just what the amplitude and wave shape of the output pulse will be. It is the purpose of this paper to attempt to answer these questions as well as some others.

Mathematical Analysis

Derivation of a mathematical expression describing the behavior of this type of differentiating circuit is simple and straightforward. One has but to set up the Kirchhoff voltage equations for this circuit and solve the resulting first order linear differential equation.

Let the differentiating circuit be as represented in Table 1. Applying Kirchhoff's law to this circuit one obtains the following voltage equations

$$e_i = \left(\frac{1}{C_1} + \frac{1}{C_2}\right)\int i_1 dt - \frac{1}{C_2}\int i_2 dt \qquad (1)$$

$$0 = -\frac{1}{C_2}\int i_1 dt + \frac{1}{C_2}\int i_2 dt + Ri_2 \qquad (2)$$

By differentiating both Eq. (1) and (2) with respect to time and then eliminating i_1 from the two resulting equations, one gets a differential equation in i_2

$$R\frac{di_2}{dt} + \frac{i_2}{C_1 + C_2} = \frac{C_1}{C_1 + C_2}\cdot\frac{de_i}{dt} \qquad (3)$$

But because $e_o = i_2R$ one can convert Eq. (3) into a differential equation in e_o, i.e.

$$\frac{de_o}{dt} + \frac{e_o}{R(C_1 + C_2)} = \frac{C_1}{C_1 + C_2}\frac{de_i}{dt} \qquad (4)$$

Equation (4) is a common first order linear differential equation which may be solved in the conventional way by means of the integrating factor, $\epsilon^{t/R(C_1 + C_2)}$ yielding.

$$e_o = \frac{C_1}{C_1 + C_2}\epsilon^{-t/R(C_1 + C_2)} \times \int_0^t \epsilon^{t/R(C_1 + C_2)}\cdot\frac{de_i}{dt}dt \qquad (5)$$

Equation (5) gives the response of the differentiating circuit to an input voltage of any form. To make practical use of this equation it is necessary to express the input voltage as a differentiable function of time.

It should be observed that the lower limit of the integral of Eq. (5) is zero. This follows from the assumption that the differentiating circuit is at rest when the input voltage is applied to the circuit at $t = 0$. This assumption also implies that the square wave is longer than the output pulse if the square wave is one of a train of square waves.

Square Wave Input Voltage

In recent applications, television being one of the common and

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Differentiating Circuit Analysis

By G. P. OHMAN
Naval Research Laboratory
Washington, D. C.

widely known ones, practice is to differentiate the front or back of a square-wave voltage to obtain a sharp-pulse voltage. Because the differentiation of square waves is therefore relatively important, and because of the impracticability of considering all the possible wave shapes only the differentiation of square waves will be considered further.

It was previously pointed out that one never encounters true square waves in practice since their fronts and backs have finite slopes usually approximately exponential in form. A square wave having an exponential front will be assumed. Let this voltage be represented by the expression $e_i = E_i\,(1 - \epsilon^{-t/\tau_i})$ where the terms are as defined in Table 1.

This expression gives only the rise of the square wave, not the fall, but this is not a serious limitation because the front and the back of the square wave can be considered separately. If the back of the square wave is similar in form to the front, a pulse similar to that generated in the differentiating circuit by the front, will be generated by the back, but of opposite polarity.

If one differentiates the above expression for e_i with respect to time, substitutes it in Eq. (5) and performs the indicated integration, one arrives at the expression

$$e_0 = \frac{E_i C_1}{\tau_i (C_1 + C_2)} \cdot \frac{1}{\dfrac{1}{R(C_1 + C_2)} - \dfrac{1}{\tau_i}} \times \left(\epsilon^{-t/\tau_i} - \epsilon^{-t/R(C_1 + C_2)}\right) \qquad (6)$$

Equation (6) is unwieldly, but by substituting τ_o, β, γ and T as defined in Table I, it can be simplified to

$$e_0 = E_i \gamma\,(\epsilon^{-\beta T} - \epsilon^{-T})/(1 - \beta) \qquad (7)$$

For the purpose of plotting, however, this expression is uns able because it contains too m variables. But E_i and γ ap only as simple multipliers

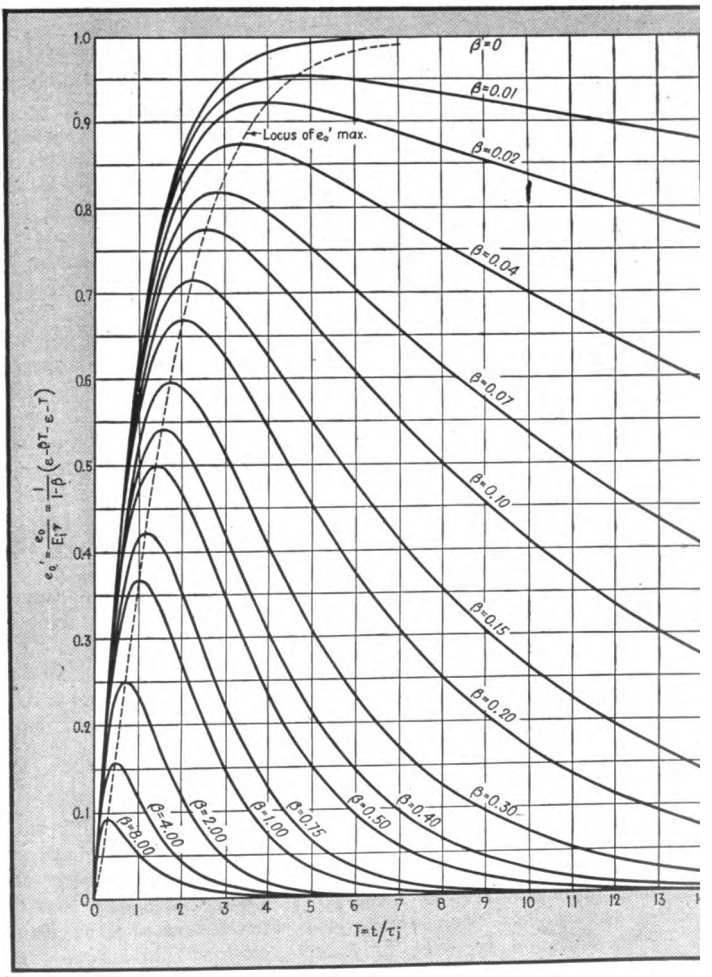

FIG. 1—Family of curves for relative pulse amplitude vs relative time shows the effect on the pulse amplitude and length of the ratio of the input wave-front time constant to the differentiating circuit time constant

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hence have no effect upon pulse shape other than its amplitude. By letting $e_o' = e_o/E_i\gamma$, one obtains an expression which may be plotted as a family of curves.

$$e_o' = \frac{1}{1-\beta}(\epsilon^{-\beta T} - \epsilon^{-T}) \qquad (8)$$

Figure 1 is a plot of Eq. (8).

Pulse Amplitude and Delay

Two other quantities which are of importance are the peak voltage reached by the output pulse and the time interval after the arrival of the square wave at which this occurs. Both of these quantities depend upon the value of β. These quantities may be found by maximizing Eq. (8).

$$\frac{de_o'}{dT} = \frac{1}{1-\beta}(-\beta\epsilon^{-\beta T} + \epsilon^{-T}) = 0$$

$$\text{or } \epsilon^{-T} = \beta\epsilon^{-\beta T} \qquad (9)$$

Substituting Eq. (9) into Eq. (8) one finds that

$$e_o'_{\max} = \epsilon^{-\beta T} \qquad (10)$$

Eliminating T from Eq. (9) and (10), one obtains

$$e_o'_{\max} = \left(\frac{1}{\beta}\right)^{\beta/(\beta-1)} \qquad (11)$$

Solving Eq. (9) for T

$$T \text{ for } e_o'_{\max} = \frac{1}{\beta - 1}\log_\epsilon \beta \qquad (12)$$

Equations (11) and (12) are plotted in Fig. 2.

In addition to the curves already mentioned a third set of curves, given in Fig. 3, has been calculated and plotted, which gives an indication of pulse length as a function of β. Pulse length is defined as the time at which the pulse voltage has decayed to a certain percentage of the maximum pulse voltage. Figure 3 gives the T at which the pulse amplitude has decayed to 10 percent and to 1 percent of its maximum value.

Use of Charts

It is tacitly assumed in the derivation of these formulas and curves that the differentiating circuit has negligible loading effect upon the square-wave voltage source. This is not likely to be the case if the source impedance is relatively high compared to the impedance of the differentiating circuit. This should be kept in mind when one chooses the parameters of the differentiating circuit since loading of the voltage source will increase the time constant τ_i of the input wave front. In some cases allowance may have to be made for loading.

On Fig. 1 e_o' and T are pure numerics and do not per se represent voltage and time respectively. e_o' must be multiplied by $E_i\gamma$ to obtain the output voltage, e_o, and T must be multiplied by τ_i to convert the abscissa scale to a time scale. If this is done the curve corresponding to the proper β will be a chart of the output voltage as a function of time. The curve corresponding to $\beta = 0$ will be a chart of the input voltage if the ordinate scale is multiplied by E_i alone and the abscissa scale is multiplied by τ_i.

Frequently one wants to know the maximum voltage reached by the output voltage pulse and the time at which this maximum occurs; Fig. 2 gives this information. Here again e_o' and T must be treated in the same way as on Fig. 1.

It can be seen upon examination of Fig. 1 that no matter how great β is, that is—no matter how sharply one differentiates the input wave, the front of the output pulse never has a slope greater than that of the input wave. However, increasing β has two desirable effects; it shortens the length of the pulse, and it reduces the time necessary for the pulse to reach its maximum value. Increasing β has one very undesirable effect; the maximum pulse amplitude decreases, consequently it is not generally practical to make β very large.

Examination of Eq. (7) shows that one should keep C_2 as small as possible; a large C_2 in comparison to C_1 results in loss in amplitude of the output voltage pulse because γ becomes appreciably less than unity. A large C_2 also increases the time constant of the differentiating circuit.

Illustrative Problem

Response of a given differentiating circuit to a given square wave may quite readily be found using the formulas and charts that have been derived and plotted. For example, suppose that a square wave of 100 volts amplitude and having a front whose time constant is 0.25 microsecond is applied to a differentiating circuit in which $C_1 = 90\ \mu\mu f$, $C_2 = 10\ \mu\mu f$, and $R = 5000$ ohms, and suppose one wants to answer the questions:

(1) What is the equation of the output voltage pulse?

(2) What is the maximum output voltage?

(3) At what time will the maximum voltage be reached?

(4) What is the pulse length, i.e., when will the pulse voltage decay to 1 percent of its maximum value?

To answer question (1) we calculate τ_o, β, γ, and T from their equations as given in Table I, obtaining

$\tau_o = 0.50$ microsecond

$\beta = 0.50$ (coincidence that $\beta = \gamma_o$)

$\gamma = 0.90$

$T = 4.0t \times 10^6$

These values are substituted in Eq. (7), giving for the output-pulse voltage as a function of time the equation

$$e_o = 180(\epsilon^{-2t\times10^6} - \epsilon^{-4t\times10^6})$$

This equation corresponds to the curve $\beta = 0.50$ in Fig. 1.

Question (2) is answered by finding the $e_o'_{\max}$ for $\beta = 0.50$, in Fig. 1 which is 0.50 coincidentally, and multiplying this value by $E_i\gamma$, or $e_{o\max} = (0.50)(100)(0.90) = 45$ volts.

Figure 2 is also used to answer question (3). One finds the T for $e_o'_{\max}$ corresponding to $\beta = 0.50$ and multiplies by τ_i, thus t for $e_{o\max} = (1.40)(0.25) = 0.35$ microseconds.

The answer to question (4) is found with the aid of Fig. 3 which shows T for decay to 1 percent of the maximum to be 12.1 for $\beta = 0.50$. This T times τ_i gives the pulse length in time, which is 3.78 microseconds.

Design Difficulties

The problem of design, as is usually the case, is more difficult than the problem of analysis. Given a square wave with certain amplitude and rise time it may not be possible to design a differentiating circuit which will produce an output pulse having simultaneously all of the desired characteristics of pulse amplitude, pulse length, and time for pulse to reach its maximum value. It may not be pos-

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sible even to satisfy the requirement of pulse amplitude alone, although the requirements of pulse length and time required to reach a maximum may usually be met by differentiating sufficiently sharply.

Unfortunately, as was previously pointed out, the more sharply one differentiates, i.e., the greater is β, the smaller will be the magnitude of the output pulse so it is not generally advantageous to differentiate any more sharply than necessary. Because of this close interdependence of pulse characteristics, one is usually forced to design the differentiating circuit to meet the most urgent requirement first and then to try to satisfy the others if possible.

As an example of design, suppose one wishes to design a differentiating circuit which will produce a pulse of at least 40 volts maximum amplitude and that this maximum should be reached as quickly as possible, given a square-wave input voltage of 100 volts amplitude and having a rise whose time constant is 0.25 microsecond.

A number of assumptions will have to be made in solving this problem. One is in regard to C_s. If the differentiating circuit is isolated this stray capacitance C_s is ordinarily quite small, perhaps 1 or 2 $\mu\mu$f, but if the differentiating circuit is in close physical proximity to other circuits, and especially if the output is connected to a vacuum tube, C_2 is likely to be higher, say in the order of 10 $\mu\mu$f. In this example a C_s of 10 $\mu\mu$f will be assumed.

Another assumption is in regard to γ. Ordinarily one would like γ to be close to unity, but this means choosing a large C_1. If C_1 is large, R must be small in order to differentiate sharply. A small R would make the impedance of the circuit low and possibly load the voltage source to such an extent that the advantage of differentiating sharply would be lost. Usually it is not practical to make γ much larger than 0.90; often, it has to be made smaller. In this example a γ of 0.90 will be chosen since a relatively high output voltage is the principal requirement. It will be seen subsequently that choosing a γ at this point is equivalent to choosing a C_1 and fixing the value of R.

Calculations

Now because γ has been chosen as 0.90 and C_s as 10 $\mu\mu$f, C_1 will have to be equal to 90 $\mu\mu$f as given by $\gamma = C_1/(C_1 + C_s) = 0.90$. Given an e_{omax} of 40 volts, e'_{max} will have to be $e'_{max} = e_{omax}/E_i\gamma = 40/(100 \times 0.90) = 0.45$. On Fig. 2, corresponding to this value of 0.45 one finds that β can not be greater than 0.65. This means that $\tau_o = \tau_i/\beta = 0.25/0.65 = 0.47$ microsecond. But $\tau_o = R(C_1 + C_s)$, hence $R(90 + 10) \times 10^{-12} = 0.47 \times 10^{-6} = 4700$ ohms.

As a matter of interest one can find, using Fig. 2 and 3, that t for $e_{omax} = \tau_i T$, where T is taken at e_{omax}, is $0.25 \times 1.23 = 0.31$ microsecond, and that the time at which the pulse has fallen to 1 percent of its maximum value is $\tau_i T$, where T is taken at 1 percent, is $0.25 \times 9.9 = 2.25$ microseconds.

As an example of designing a differentiating circuit for a desired pulse length, suppose one wants the pulse to be down to 1 percent of its maximum value in 1.50 microseconds, given the same input voltage as in the previous example; what must the circuit parameters be?

To find the value of T corresponding to the 1-percent time we divide the pulse length of 1.50 microseconds by τ_i, which is 0.25 microsecond, giving 6.00. From Fig. 3, for this value of T we find that β is 1.92 hence $\tau_o = R(C_1 + C_s) = \tau_i/\beta = 0.25/1.92 = 0.13$ microsecond.

Now again an assumption must be made. One can either assume a value for $C_1 + C_s$ and solve for R, or vice versa. In this example a resistance of 3900 ohms will be chosen.

As has been previously pointed out, the minimum permissible value of R is determined by the impedance of the voltage source. If one assumes a value for $C_1 + C_s$ and this assumption results in a value for R which is too low, a smaller value of $C_1 + C_s$ must be assumed. Consequently it is usually advisable to select a value for R and solve for $C_1 + C_s$ if either may be chosen. Sometimes, however, as in the previous example, it makes the solution of the problem simpler if a value for $C_1 + C_s$ is chosen instead. If R is taken as 3900 ohms, $C_1 + C_s = \tau_o/R = 0.13 \times 10^{-6}/3900 = 33$ $\mu\mu$f.

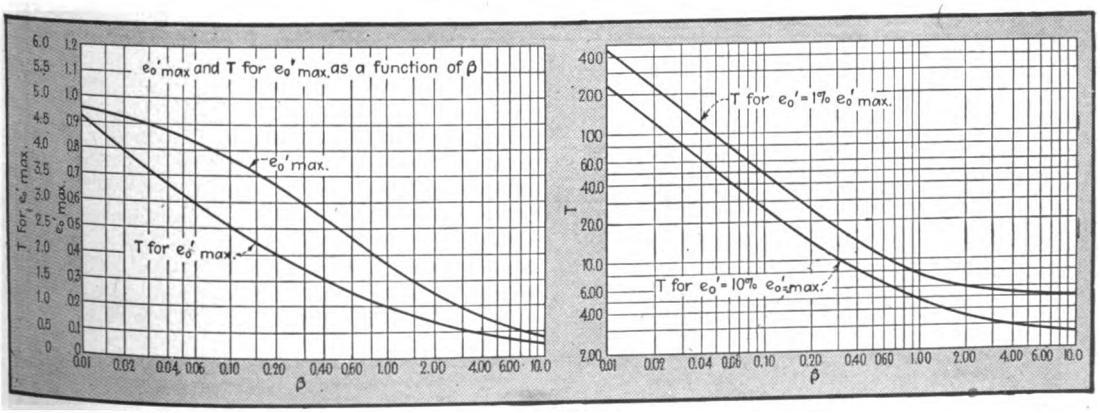

FIG. 2—For use in designing R-C differentiating circuits, these curves give relative amplitude and time for pulse maximum

FIG. 3—Curves, giving relative time for the pulse to decay to a small percent of its maximum, indicate pulse length

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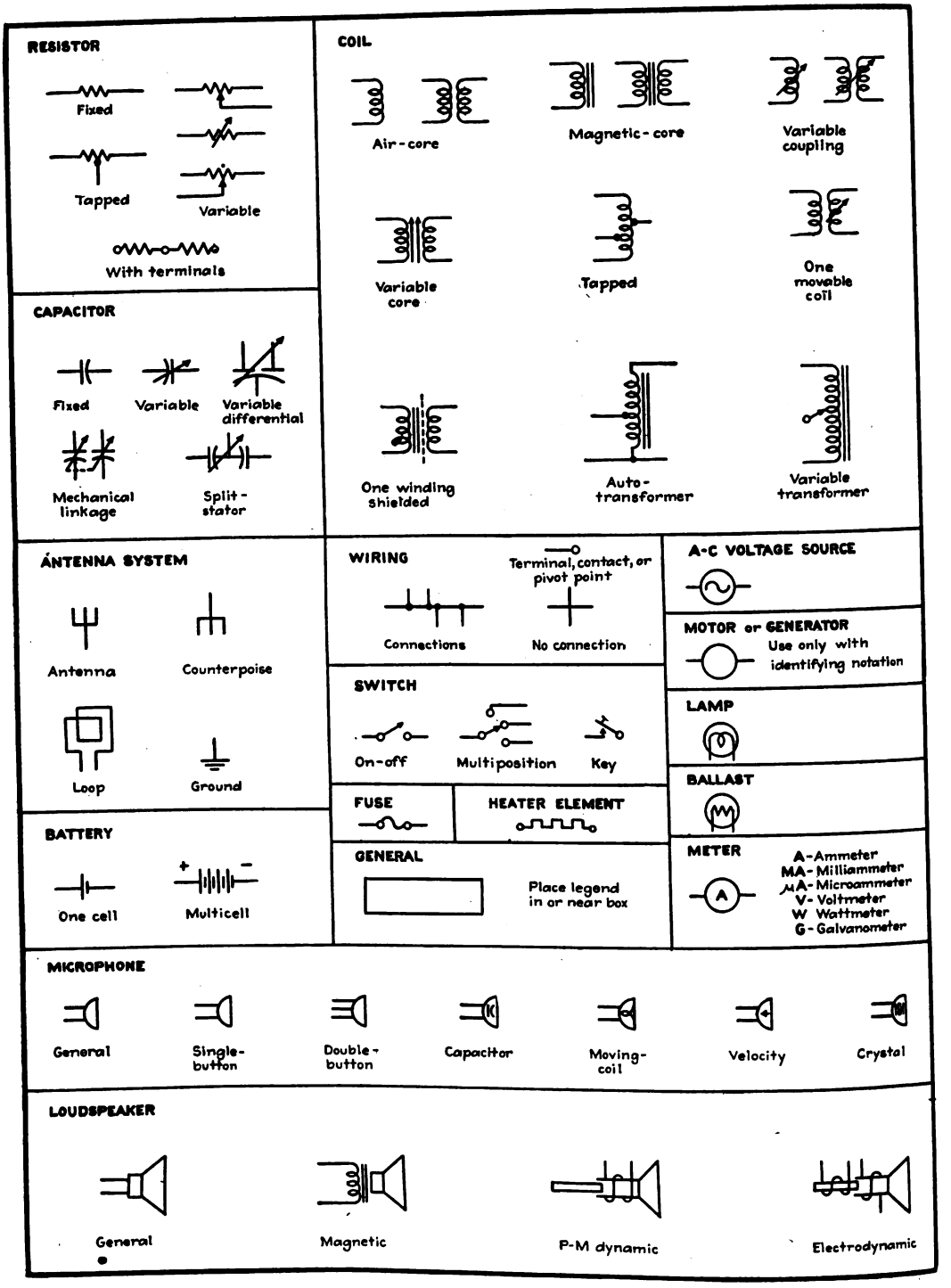
Graphical Symbols for



ELECTRONICS REFERENCE SHEET

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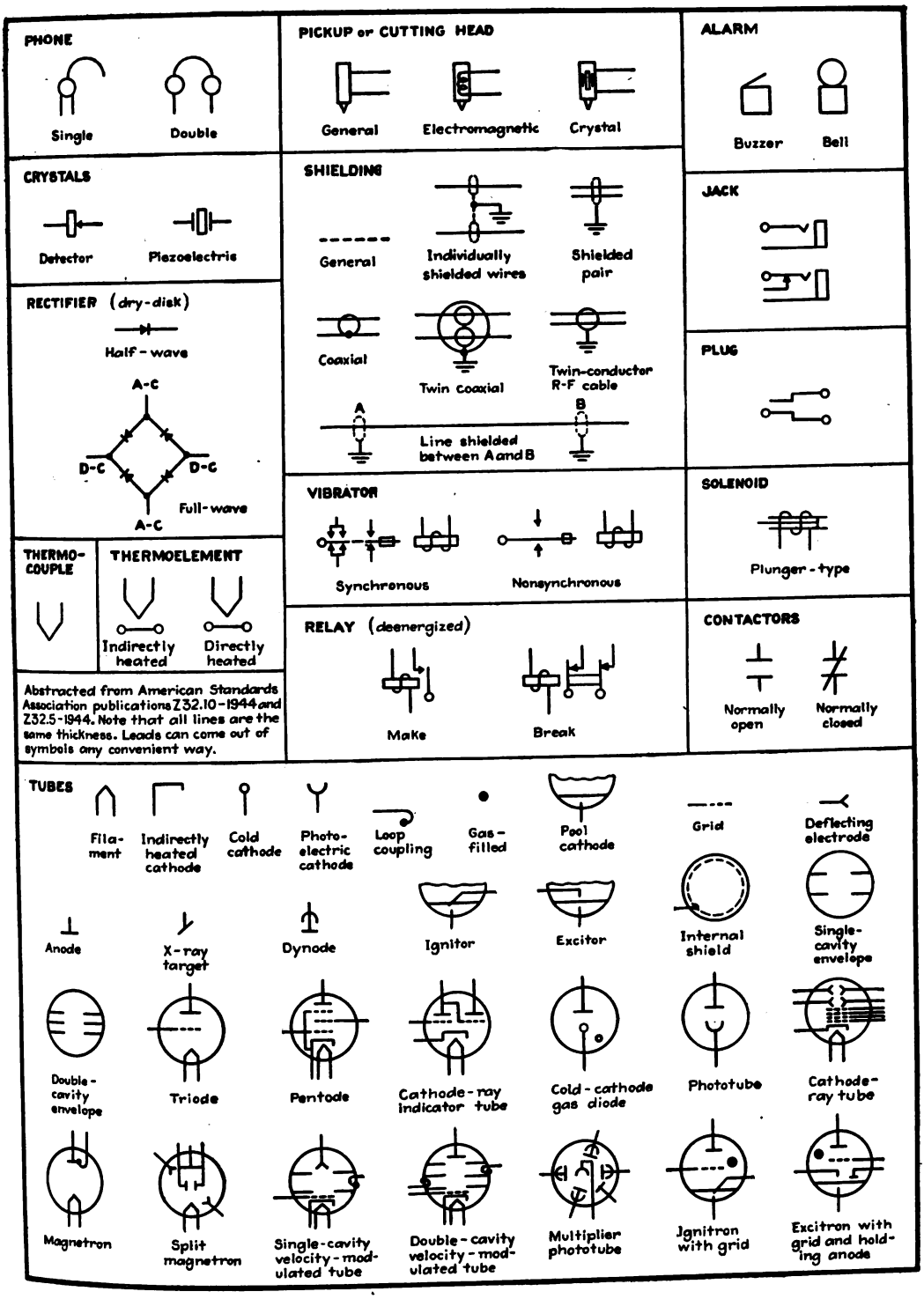
Electronic Diagrams



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Stabilized NEGATIVE

Variations with frequency of amplifier characteristics cause variations of real and imaginary components of negative impedance which is produced. Power handling capacity of the amplifier limits the magnitude of negative impedance that can be produced

By E. L. GINZTON

Research Engineer
Sperry Gyroscope Company, Inc.
Garden City, N. Y.

AMPLIFICATION A was assumed in Part I to be a real constant. While this may actually be so in a practical amplifier within a certain frequency domain, it is not so at all frequencies between zero and infinity.

Amplifier Phase Shift

The simplest type of amplifier suitable for producing negative impedances is a two-stage, direct-coupled amplifier the power for which is supplied by an essentially zero-impedance source. Even in this simple case there are shunting capacitances in the tubes and wiring so that although at low frequencies the amplification is real, at higher frequencies, there is phase shift and obviously the character of the negative impedances that can be obtained by means of such an amplifier will not be the simple negative of the positive impedance which is used in conjunction with that amplifier.

If one considers a high gain amplifier with pentode tubes which utilize filter networks in the screen grid and cathode circuits and rectifier-type power supplies, the phase shift may take a complicated form and the resultant negative impedance will differ greatly from the simple form which would be expected if the phase shift were neglected.

In general, a properly designed amplifier will have a region where the amplification parameter is nearly constant and where the simple equations developed in the Part I hold. Outside of this region phase shift will occur, and the gain of the amplifier will contain an imaginary component. If G is the actual gain of the amplifier, G_o is the absolute value of the amplifier gain in the region where the phase-shift is zero or negligible, and θ is the phase shift in degrees referred to the zero phase-shift region, then the gain may be expressed as $G = G_o(\cos\theta + j\sin\theta)$. This can be written as

$$G = G_r + jR_i \qquad (30)$$
$$\text{where } G_r = G_o\cos\theta$$
$$G_i = G_o\sin\theta$$

Both G_o and θ must be known for all frequencies before the nature of the negative impedance can be completely specified.

Phase-Shift Effect on Shunt Negative Impedance

Substituting the vector relation for amplifier gain given by Eq. (30) in Eq. (13) (Part I), one obtains for negative impedance the equation

$$Z_n = \frac{Z_2}{1 - (G_r + jG_i)} \qquad (31)$$

Which can be rewritten in the form

$$\frac{1}{Z_n} = \frac{1}{Z_2/(1 - G_r)} + \frac{1}{jZ_2/G_i} \qquad (32)$$

Equation (32) is a familiar expression for two impedances in parallel, and the corresponding circuit is shown in Fig. 10(a). The real part is recognized as the shunt negative impedance proper, and the imaginary part represents an imaginary term which disappears when the imaginary part of the amplifier gain is zero. For the sake of convenience, the functions which determine the real and imaginary parts of the shunt negative impedance will be defined as follows

$$Z_n = \frac{1}{(1/Z_2F_1) + (1/jZ_2F_2)} \qquad (33)$$

PART I

Basic ideal circuit and fundamental equations for producing the negative of a positive impedance. Eq. (1)-(29), Fig. 1-9, Ref. 1-10

PART II

Effective on negative impedance of variations with frequency of amplifier parameters. Eq. (30)-(56), Fig. 10-20, Ref. 11-13

PART III

Illustrative applications of negative impedances show how improved circuits can be obtained. Eq. (57)-(67), Fig. 21-27, Ref. 14-16

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IMPEDANCES . . . Part II

where $F_1 = \dfrac{1}{1 - G_r}$

$$F_2 = \frac{1}{G_i}$$

Phase Shift Effect on Series Negative Impedance

The effect of phase shift upon the character of the series negative impedance can be obtained by substituting Eq. (30) in Eq. (14) and letting $Z_3' = Z_3 + R_3$ as was done in Eq. (23).

$$Z_n = Z_3'(1 - G_r) + R_1 - jZ_3'G_i \quad (34)$$

where R_1, the output impedance of the amplifier as before, must now be considered a function of frequency. This equation can be rewritten as

$$Z_n = Z_3'F_3 + R_1 + jZ_3'F_4 \quad (35)$$

where $F_3 = 1 - G_r$
$F_4 = -G_i$

The series circuit expressed by Eq. (35) is shown in Fig. 10(b). When $G_i = 0$, the complex form of the series negative impedance reduces to the simple conception of the negative impedance discussed earlier. The resistance R_3 must be so adjusted that in the region where $G_i = 0$ the negative resistance due to R_1 just cancels the output impedance of the amplifier. This cancellation obviously cannot hold outside this region because both the magnitude of the series negative resistance due to R_3, and the output impedance of the amplifier are changing and in general these changes will not counteract one another. The variation of output impedance of the amplifier with frequency due to phase shift and negative feedback is discussed later.

Calculation of Phase-Shift Effect

If the phase shift and the absolute magnitude of the gain G of an amplifier are known, then functions F_1, F_2, F_3, and F_4 can be computed and the nature of the negative impedance outside the domain of constant G can be determined. This

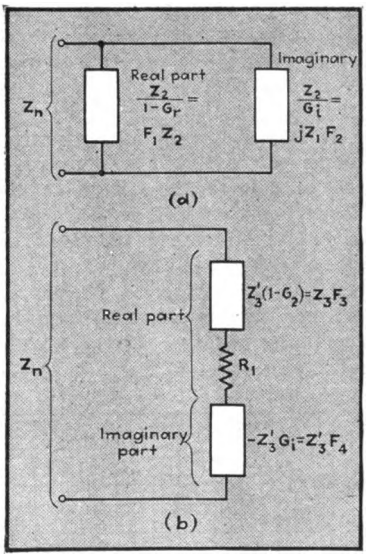

FIG. 10—Effect of phase shift in the amplifier is to produce a change in magnitude of the real component of the negative impedance, and to introduce an imaginary component (a) in parallel with shunt negative impedance, or (b) in series with series negative impedance

means that the exact nature of the amplifier and the types of coupling must be known, as well as the amount of negative feedback used within the amplifier.

To facilitate computation of the above functions, Fig. 11, 12, 13 and 14 give the functions in terms of the amount of phase shift and gain G_o. These are merely graphical forms of the Eq. (33) and (35) from which the effect of phase shift and the gain for any amplifier on the character of either the shunt or series negative impedance may be obtained.

As an example, Fig. 15 shows a two-stage amplifier with resistance-capacitance coupling and utilizing a moderate amount of negative feedback. The phase shift and the absolute magnitude of the gain for this amplifier are also shown. From these curves and Fig. 11 and 12, F_1 and F_2 were obtained as functions of frequency, and are shown in Fig. 16.

Fig. 16 shows that the function F_1, which determines the character of the real part of the shunt negative impedance, changes sign abruptly at both low and high frequencies and thus changes the negative impedance into a positive one. In the mid-frequency region, F_1 remains remarkably constant, which means that the negative impedance also is very nearly constant. On the other hand, the imaginary component of the negative impedance introduces an appreciable effect long before the real part changes sign. Once Fig. 16 has been obtained for an amplifier the exact nature of the negative impedance that will be developed by means of that amplifier can be obtained by Eq. (33) or (35).

Illustration of Effect of Phase Shift

An example of a shunt negative resistance, obtained by means of the amplifier shown in Fig. 15 whose characteristics are described by Fig. 15 and 16, is shown in Fig. 17. These curves were obtained by the method outlined above and checked experimentally by measuring the input impedance of the amplifier as a function of frequency by means of a Wheatstone bridge.

These curves show that the real part of the negative resistance, in the region between 600 and 30,000 cps, is negative. Between approximately 1,000 and 15,000 cycles its value could have been obtained directly by Eq. (13), neglecting phase shift in the amplifier. At frequencies lower than 60 and higher than 30,000 cps the negative resistance changes sign and actually becomes positive. At the extreme frequencies, i.e., at zero and infinity, the amplification of the amplifier is zero, and the input impedance of the amplifier is simply R_3 in series with the output impedance of the amplifier.

These curves also show that even at mid-frequencies the input impedance of the amplifier contains a reactive component. In accordance with the sign of function F_3

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shown in Fig. 16 the reactance is capacitive at the high frequencies and inductive at the low frequencies. As will be observed from Fig. 16 and 17, the reactive component of the negative resistance is minimum at approximately the same points where the real component becomes infinite.

Limitations Imposed by Phase Shift

In the region between 400 and 5,000 cps the reactive component is ten or more times the real component, therefore the former may be neglected in this region. In the case of negative resistance, the useful range of the negative resistance on the frequency scale must be inside these types of limits, and what happens outside may or may not be of importance. However, if it were a negative reactance that were obtained by means of this amplifier, it is obvious that the imaginary component will contribute a resistance component to the desired negative reactance. In this case it is imperative to know the behavior of the imaginary component for all values of frequency and not merely be satisfied with the knowledge that the resistive component is negligible in the useful range.

The reason for this is that either at the low or high frequencies, depending upon what kind of reactance is being developed by the amplifier, the imaginary component will produce a negative resistance which may cause oscillations in the amplifier. It is plain, therefore, that in no case may the quadrature component of a negative reactance be disregarded, but, on the contrary, its behavior as a function of frequency must be studied carefully, especially in the neighborhood of the point where the real part of the negative reactance becomes infinite in the case of the shunt negative reactance or zero in the case of the series negative reactance.

Advantages of Direct-Coupled Amplifier

A two-stage resistance-capacitance amplifier shown in Fig. 15 has 180-degree phase shift at the low-frequency end, which, according to Fig. 16, means that a negative resistance will be developed by a shunt negative inductance circuit of magnitude $L_s F_s$, where L is the inductive reactance. The complete results are too complicated to present in a general form. In a special case of a two-stage amplifier with resistance-capacitance coupling, Table I summarizes what is to be expected.

Table I shows that the resistive component developed by a negative reactance in the case of an amplifier capable of 180-degree phase shift at either end of the frequency range is always negative at one end or the other. Therefore, extreme caution must be used in combining negative reactance with other elements.

By means of a direct-coupled amplifier it is possible to obtain negative reactances which do not have a negative resistance component. Referring to Table I, it is seen that a shunt negative inductance has a negative resistance component at the low frequencies. If a direct-coupled amplifier is used, the negative inductance will not have a resistive component at the low-frequency end; only a positive resistive component at high frequencies will be present. Similarly, a negative capacitance may be obtained which does not have a negative resistive component if a direct-coupled amplifier is used to produce series negative capacitance.

Negative resistance, according

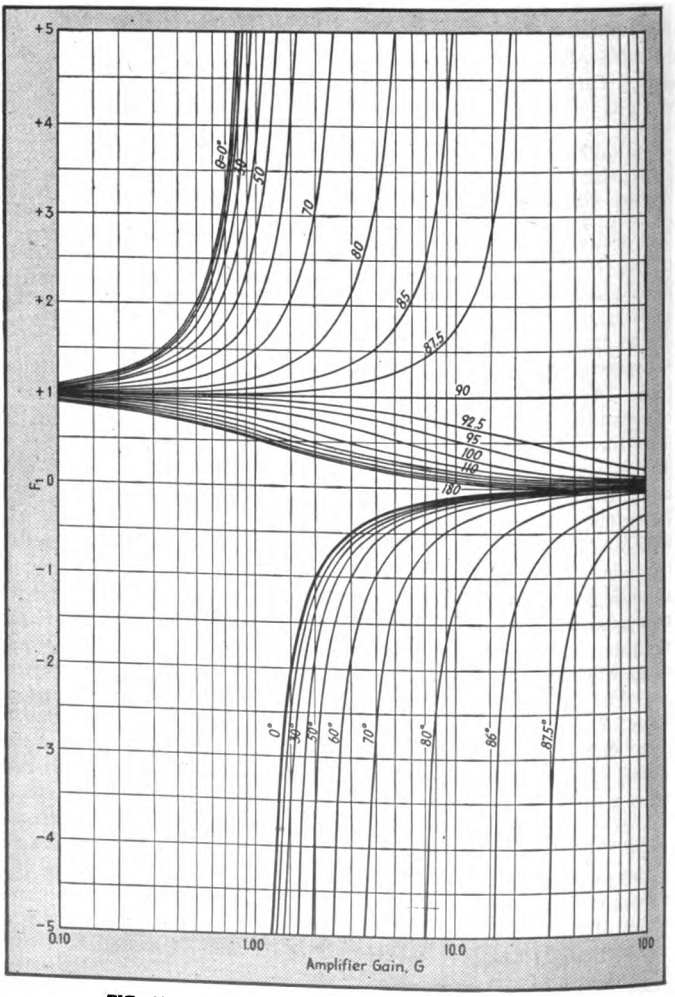

FIG. 11—Variation of F_1 with amplification for use in predicting effect of phase shift on negative impedance

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to its definition, must be able to supply power to the circuit to which it is connected. This involves a source of power in the network and because all actual devices have a finite source of power, the range of the negative characteristic must be necessarily limited. The magnitude of negative reactance exhibited by the device is also limited by the same factors as the negative resistance because negative reactances must supply power to the circuit on one half of the cycle and absorb power on the other half cycle.

Energy Storage of Negative Reactances

If a sinusoidal voltage whose crest value is e forces a current of crest value i through an impedance Z, then the following relations may be written

$$P = e^2/2Z \quad (36)$$

$$P = i^2Z/2 \quad (37)$$

where P is average power dissipated during the cycle in the case of resistance, and average energy stored in inductance or capacitance during the cycle in the case of reactance.

Power Limit of Series Negative Impedance

In the case of series negative impedance it is easiest to think in terms of the current that the amplifier can handle. This current is determined by the properties of the amplifier in the following manner.

If E_o is the maximum output voltage of the amplifier, then the maximum input voltage that can be developed at the input of the amplifier is E_o/G, where G is the voltage gain of the amplifier. Let I be the maximum current that it is desired to obtain from the negative resistance. It is obvious that impedance Z_s' must not exceed the value which will make the voltage developed across it equal to the maximum allowable voltage. Thus Z_s' must not be greater than

$$Z_{s'max} = E_o/GI \quad (38)$$

Substituting this value of Z_s' into Eq. (12) and (14), it is seen that the magnitude of the negative impedance is determined by the factory E_o/I

$$Z_{nmax} = R_1 + (E_o/GI)(1 - G) \quad (39)$$

This equation states that the magnitude of the negative impedance a given amplifier is capable of developing depends upon the current that it is desired to draw from the amplifier.

Optimum Power of Series Negative Impedance

From Eq. (37) it is plain that the power-handling capability is proportional to the magnitude of the impedance of the circuit and the square of the current through the circuit. Combining Eq. (37) and (39), the power-handling capacity of the series negative impedance is

$$P = \tfrac{1}{2}I^2R_1 + (E_oI/2G)(1 - G) \quad (40)$$

For any given amplifier there is a value of current at which the maximum possible P (measured in volt-amperes) can be developed by the negative impedance. This critical current may be obtained by differentiating Eq. (40) with respect to I and equating the result to zero. This gives

$$(\partial P/\partial I) = IR_1 + (E_o/2G)(1 - G) = 0$$

$$I_{max} = \frac{E_o}{2R_1} \cdot \frac{G - 1}{G} \quad (41)$$

From which the maximum volt-amperes that can be developed by a series negative impedance is

$$P_{max} = -\frac{E_o^2}{4R_1} \cdot \frac{1 - G}{G} \quad (42)$$

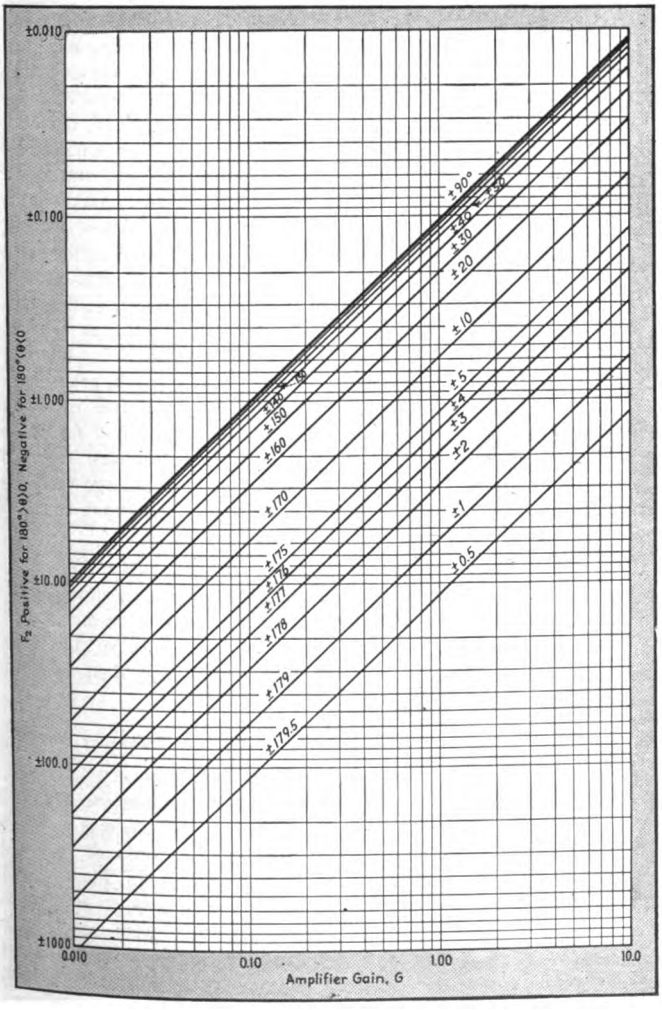

FIG. 12—Variation of F_s with amplifier gain. Figures 11 and 12 are for shunt negative impedance

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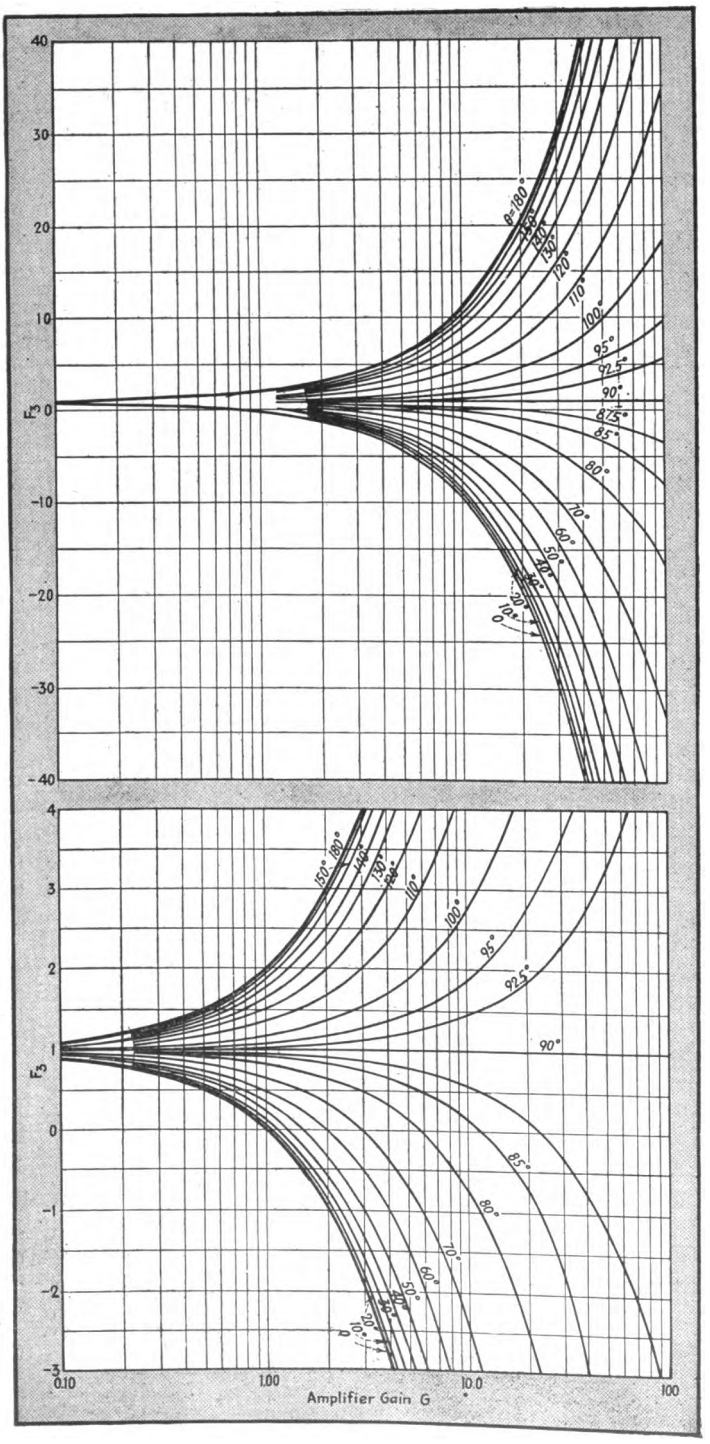

FIG. 13—Variation of F_3 with magnitude and phase of amplification, below is a detail of the middle portion

If the maximum current I approaches the value for which Eq. (40) becomes zero, the power capability also approaches zero.

An example of a negative resistance that can be developed by an amplifier, together with its power capability is plotted in Fig. 18. It shows, for instance, that the actual amplifier cannot handle unlimited values of current; and that for any given amplifier and for any given maximum current, it is possible to obtain any magnitude of series negative resistance smaller in magnitude than the maximum given by Eq. (39).

Power Limit of Shunt Negative Impedances

It was assumed in the derivations of all equations that in this type of negative impedance the grid of the tube does not draw any grid current. Therefore, the peak value of the voltage that appears across the terminals of the negative impedance must not exceed the maximum allowable amplifier input voltage. This voltage is determined by two factors, namely, the direct current bias of the first tube, and secondly, the amount of negative feedback used in the amplifier. If ϵ is the maximum voltage that can be applied to the input of the amplifier without producing distortion in the output of the amplifier in the absence of feedback, and $A\beta$ is the feedback factor, then the maximum voltage that can appear across the input terminals of the amplifier is

$$e_{max} = \epsilon (1 - A\beta) \qquad (43)$$

This equation determines the maximum allowable voltage, and the power capability of the negative impedances will then be given by Eq. (36).

Amplifier Frequency Response

The most convenient type of an amplifier suitable for supplying a negative impedance is a two-stage resistance-capacitance coupled amplifier, shown in Fig. 19. It is usually desirable to stabilize such an amplifier with negative feedback to improve its stability and frequency response. The effect of negative feedback on the frequency characteristic must be precisely

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known because the frequency characteristic determines the phase shift introduced by the amplifier and this, in turn, determines the type of impedance that results in the frequency region outside the desirable one.

In the following analysis, this notation will be used

S = Effective mutual conductance of the tube
G_m = mutual conductance of the tube
R_p = Plate resistance of the tube

$$R_{eq} = \frac{R_c}{1 + (R_c/R_{g1}) + (R_c/R_p)}$$

$R = R_{g1} + R_c/(1 + R_c/R_p)$
$X_c = 1/2\pi fC_c$ = the reactance of the coupling capacitor
$X_s = 1/2\pi fC_s$ = the reactance of the shunting capacitor from plate to ground of each stage, including stray, wiring and tube capacitances
A = voltage amplification of a stage without feedback
A_o = voltage amplification in the mid-frequency region
$L = X_c/R$ = frequency variable for low frequencies
$H = R_{eq}/X_s$ = frequency variable for the high frequencies

The above notation will refer to the first stage, and if the symbols are primed, they will refer to the second stage. Thus, A is the amplification of the first stage and A' is the amplification of the second stage.

Effect of Bias Circuits

If the cathode resistors in Fig. 19 are unbypassed, then there will be a loss of gain in the stage due to current negative feedback. In the pentode amplifier, this does not modify the frequency characteristic appreciably, so that the only result will be a reduction of the mutual conductance of the tube. It can be easily shown that the effective mutual conductance of a tube is

$$S = \frac{G_m}{1 + G_m R_c} \qquad (44)$$

It will be assumed in this derivation that either the cathode is not by-passed in which case Eq. (44) holds, or that it is adequately by-passed in which case $S = G_m$. The intermediate case is of no importance because it produces additional phase shift in the amplifier and should be avoided. The additional phase shift due to the improper by-passing of cathode resistor and also of the screen grid dropping resistor is discussed in the literature.[11]

The voltage gain of an amplifier in the mid-frequency region where zero phase shift occurs is given by Terman as[12]

$$A_o = SR_{eq} \qquad (45)$$

The voltage amplification at the low frequency end of the frequency range is

$$A = \frac{A_o}{1 - jL} \qquad (46)$$

and for the high frequency end.

$$A = \frac{A_o}{1 + jH} \qquad (47)$$

These equations refer to the amplification of the first stage of the amplifier shown in Fig. 19. A similar set of equations may be written for the second stage, using the notation given above. It must be remembered that the amplification of the second stage must take into account the shunting effect of the resistances R_c and R_7.

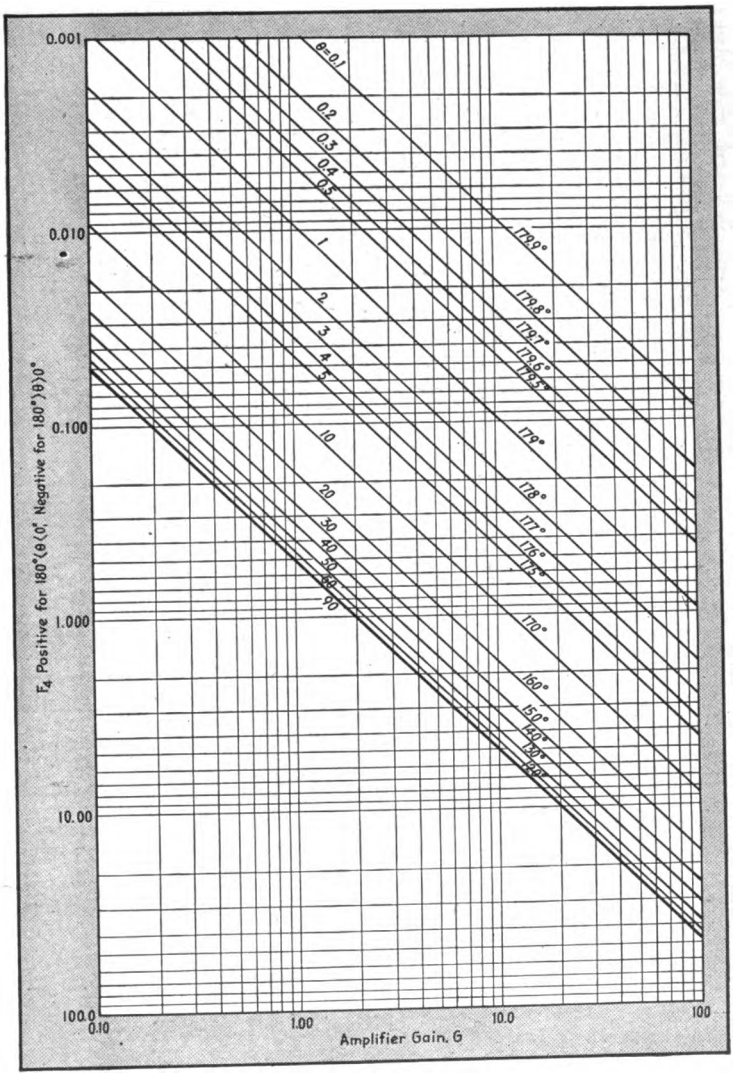

FIG. 14—Variation of F_4 with amplification. Figures 13 and 14 apply to series negative impedance

Calculation of Amplifier Response

The total voltage amplification of the amplifier will be

at low frequencies

$$AA' = \frac{A_o A_o}{(1 - jL)(1 - jL')} \qquad (48)$$

at high frequencies

$$AA' = \frac{A_o A_o'}{(1 - jH)(1 + jH')} \qquad (49)$$

The voltage gain of the amplifier including negative feedback will be

$$G = \frac{AA'}{1 - \beta AA'} \qquad (50)$$

Combining Eq. (48), (49), and

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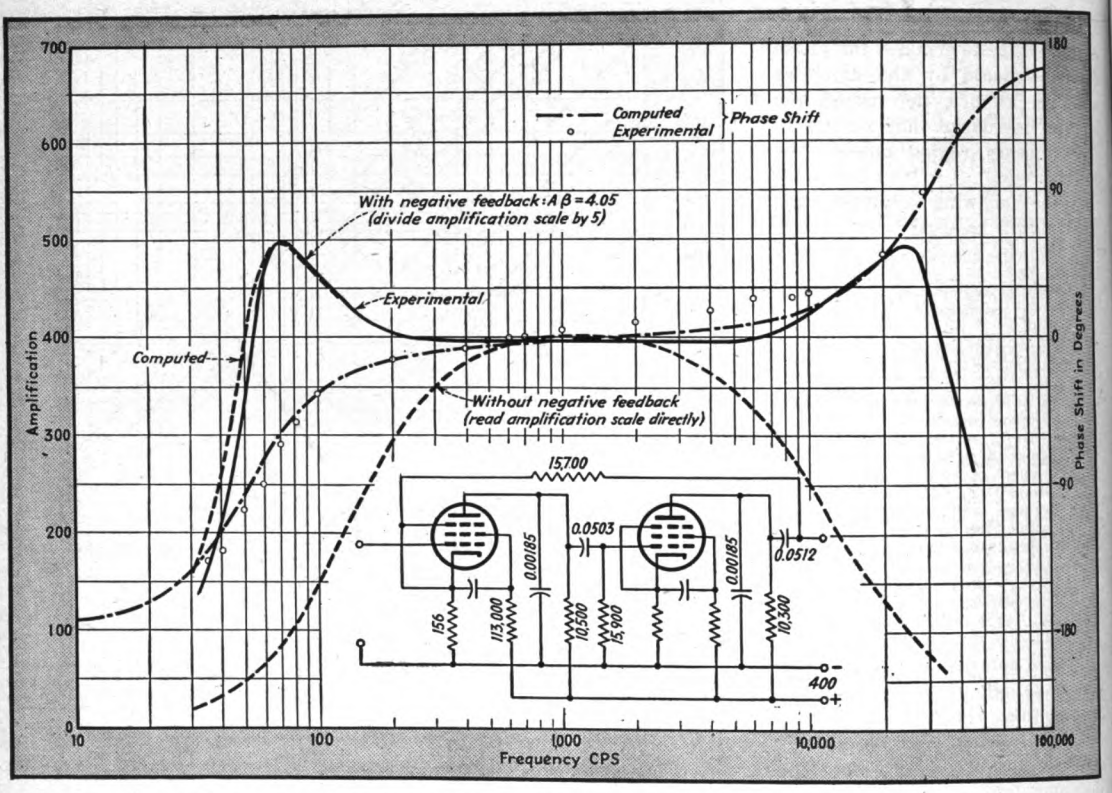

FIG. 15—Magnitude and phase shift of an amplifier from which shunt negative impedance is produced must be known as a function of frequency. The dot-dash curve is phase shift with negative feedback, other curves are gain

(50), the following results, at low frequencies

at low frequencies

$$G = \frac{-A_o A_o'}{\beta A_o A_o' - (1 - jL)(1 - jL')} \quad (51)$$

at high frequencies

$$G = \frac{-A_o A_o'}{\beta A_o A_o' - (1 + jH)(1 + jH')} \quad (52)$$

Also, assume that the second stage is a times better than the first, at the low frequencies, and b times better at the high frequencies. Or symbolically,

$$a = L'/L$$
$$b = H'/H$$

Interpretation of Response Equations

Hence, Eq. (51) and (52) can be written

at low frequencies

$$G = \frac{-A_o A_o'}{\beta A_o A_o' - (1 - jL)(1 - jaL)} \quad (53)$$

at high frequencies

$$G = \frac{-A_o A_o'}{\beta A_o A_o' - (1 + jH)(1 + jbH)} \quad (54)$$

These are vector expressions for the gain in terms of the frequency variables L and H. The absolute value of the amplification and phase shift will be found in Table II. If the absolute value of the amplification is differentiated with respect to the frequency variable, it will be found that the frequency response curve of the amplifier has peaks at the low and the high end. Table II summarizes all the pertinent information regarding the re-

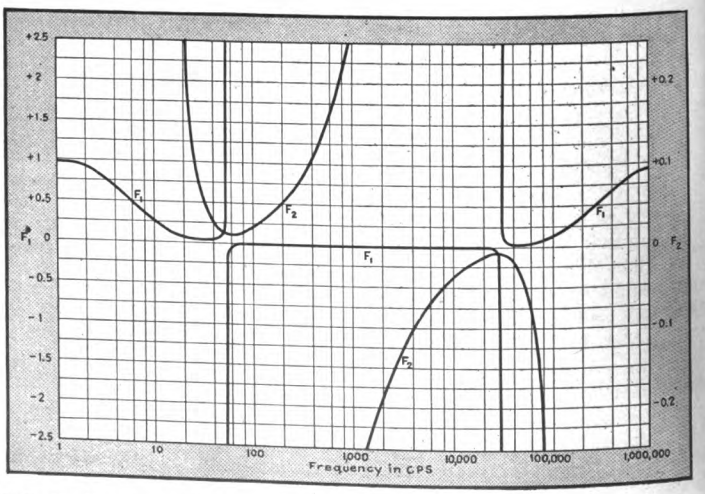

FIG. 16—Variation with frequency of gain functions of the amplifier of Fig. 15

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sponse characteristics of the negative-feedback amplifier of the type shown in Fig. 19. Figure 15 shows a typical response curve of the feedback amplifier.

Output Impedance of Amplifier

Negative impedances obtained by feedback amplifiers invariably contain a term due to the output impedance of the amplifier. If the amplifier is not stabilized by negative feedback, the output impedance R_i consists only of the parallel combination of R_{g1} and R_c in the mid-frequency range, and is affected by the coupling capacitance C_c at the low frequencies and by C_s at the high frequencies. Thus, even in the simplest possible case the output impedance is a function of frequency and is not at all constant.

When negative feedback is utilized in the amplifier, the picture becomes more complicated. As is well known, the effect of voltage feedback is to reduce the output impedance of the amplifier in the frequency range where the phase shift in the amplifier is negligible. But if phase shift in the amplifier is not neglected, there will be frequency regions where the output impedance is increased.

Effect of Feedback

Roughly speaking, output impedance of the amplifier is affected by three factors. First, if no feedback is used R_o, the physical output impedance, is a function of frequency as explained above. Secondly, in the presence of negative feedback in the amplifier, the output impedance is reduced in the mid-frequency range, but when the amplification begins to fall, the output impedance will be increased because (due to phase shift) the negative feedback will actually become positive. Thirdly, due to the coupling between the two stages, the amplification will be zero at the extreme frequency regions, the feedback effects will disappear and the output impedance will be governed by the physical output impedances.

From this it is evident that the problem of determining the output impedance of an amplifier is not simple and the exact expression must depend not only upon the characteristics of output elements but also upon the coupling between the two stages. It is possible to analyze the output impedance of an amplifier completely in the general case where the two stages of the ampilfier are different. However, the results obtained from such an analysis are so complicated that they become of little actual value and it is simpler to handle each amplifier separately. But to show the type of results that can be expected due to the various effects, a special case will be considered where the two stages of the amplifier are alike in their frequency response. While the relative magnitudes of the various effects will be different for an amplifier with dissimilar stages, the general picture will be the same. Effects due to common power-supply impedance, additional phase shift due to cathode and screen by-passing will be entirely neglected because, by proper design, they can be eliminated.

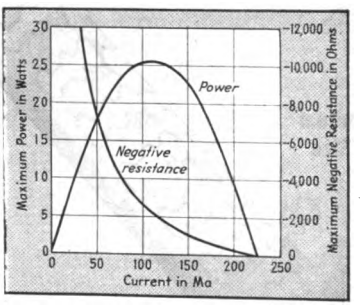

FIG. 18—For a given amplifier there is a limit to the power that can be developed by each value of negative resistance so produced

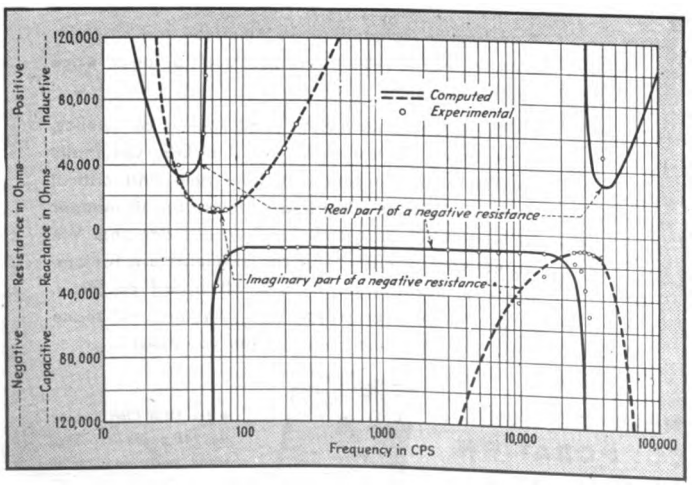

FIG. 17—Real and imaginary components of shunt negative resistance produced by the amplifier of Fig. 15

TABLE I
Resistive Component of Negative Reactance

Frequency Region	Resistive Component	
Shunt Produced Negative Reactance		
	$Z_2 = j\omega L_2$	$Z_2 = 1/j\omega C_2$
low	−	+
high	+	−
Series Produced Negative Reactance		
	$Z_3 = j\omega L_3$	$Z_3 = 1/j\omega C_3$
low	+	−
high	−	+

Calculation of Output Impedance

The output impedance of an amplifier without negative feedback may be defined as the impedance looking into the terminals 1 - 2 in Fig. 19 with the first tube of the amplifier disconnected. It will be noticed that the resistances $R_k + R_7$ are in parallel with resistance G_{g1}'. Resistance R_7 will ordinarily be so high that it will not shunt R_{g1}' appreciably, but if it does then R_{g1}' must be corrected.

at low frequencies

$$R_o = \frac{R_{g1}'(R_c' - jX_c')}{R_{g1}' + R_c' - jX_s'} \qquad (55)$$

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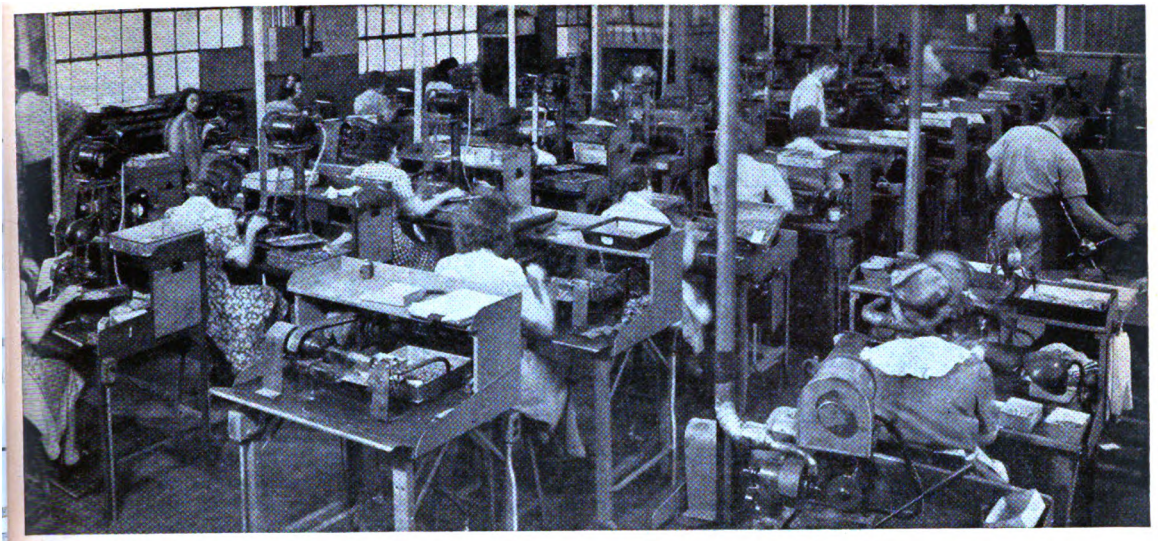

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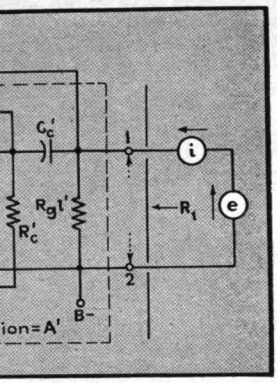

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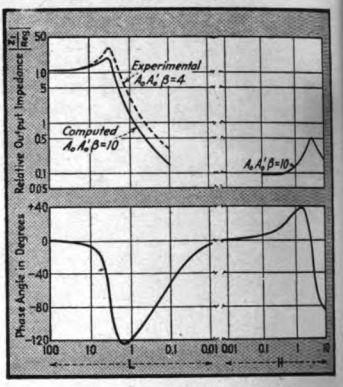

FIG. 20—Variation of amplifier output impedance with frequency affects the magnitude and angle of negative impedance

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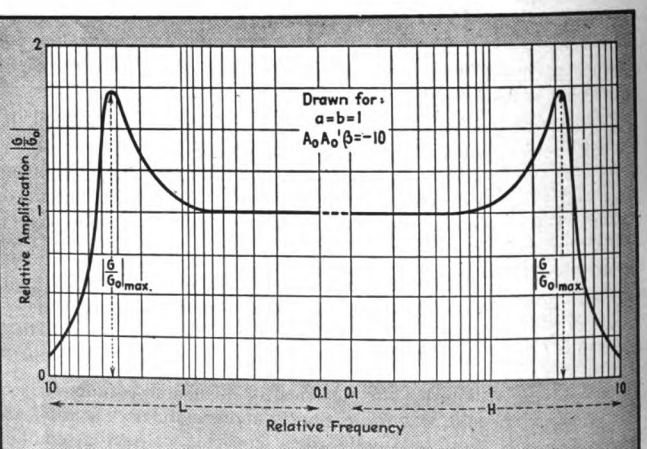

TABLE II

Frequency response characteristics of a two stage resistance-capacitance coupled amplifier with negative feedback

	Low Frequencies	High Frequencies
Frequency variable	$L=\frac{1}{2\pi f C_C R}$	$H=2\pi f C_S R_{eq}$
Vector amplification G	$-\frac{A_0A_0'}{\beta A_0A_0'-(1-jL)(1-jaL)}$	$-\frac{A_0A_0'}{\beta A_0A_0'-(1+jH)(1+jbH)}$
Phase shift	$-\tan^{-1}\frac{L(1+a)}{aL^2-(1-\beta A_0A_0')}$	$\tan^{-1}\frac{H(1+b)}{bH^2-(1-\beta A_0A_0')}$
Absolute magnitude |G|	$\frac{A_0A_0'}{\sqrt{(\beta A_0A_0'-1+aL^2)^2+L^2(1+a)^2}}$	$\frac{A_0A_0'}{\sqrt{(\beta A_0A_0'-1+bH^2)^2+H^2(1+b)^2}}$
G_0	$\frac{A_0A_0'}{1-A_0A_0'\beta}$	
$\frac{\|G\|}{\|G_0\|}$	$\frac{1}{\sqrt{\left(1-\frac{aL^2}{1-\beta A_0A_0'}\right)^2+L^2\left(\frac{1+a}{1-\beta A_0A_0'}\right)^2}}$	$\frac{1}{\sqrt{\left(1-\frac{bH^2}{1-\beta A_0A_0'}\right)^2+H^2\left(\frac{1+b}{1-\beta A_0A_0'}\right)^2}}$
Peaks occur at	$L_0=\frac{1}{2a}\sqrt{4a(1-\beta A_0A_0')-2(1+a)^2}$	$H_0=\frac{1}{2b}\sqrt{4b(1-\beta A_0A_0')-2(1+b)^2}$
$\frac{\|G\|}{\|G_0\|}_{max.}$	$\frac{1-\beta A_0A_0'}{\sqrt{\frac{(1+a)^2}{a}\left(1-\beta A_0A_0'\right)-\frac{(1+a)^4}{4a^2}}}$	$\frac{1-\beta A_0A_0'}{\sqrt{\frac{(1+b)^2}{a}\left(1-\beta A_0A_0'\right)-\frac{(1+b)^4}{4b^2}}}$

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Sandpaper Made by Electrostatic Process 208

Testing Lathe Spindles for Accuracy

AN ELECTRONIC MICROMETER which was developed to test the performance of precision lathe spindles was described by G. M. Foley, research engineer of the physics department of Battelle Memorial Institute, Columbus, Ohio, at a meeting of the Chicago section of the American Society of Mechanical Engineers during June. Accuracy of the spindles was previously measured only by the accuracy of the parts made on the machine using the spindle.

The new micrometer measures very small motions, of the order of 0.0000001 inch. It operates without mechanical or electrical contact with the moving spindle and its sensitivity is variable over a wide range of operations.

Principle of Operation

The instrument consists essentially of an oscillator whose frequency is varied by the changes in position of the spindle being measured. The output of this oscillator feels into a discriminator circuit so that changes in frequency are made visible on the screen of a cathode-ray oscilloscope.

The micrometer is used to magnify by 10,000 times the inaccuracies of the spindle, the visible pattern showing the effects of changes in operating conditions of the spindle while running. It is equally capable of making static measurements on the roundness of the spindle shaft and of the bearings of the spindle, showing the steps which should be taken to produce more precise spindles.

The micrometer has also been used to make a high-speed dilatometer to follow the crystalline changes in steels during rapid heating, and may be suitable for a number of other measuring applications requiring high speed and high sensitivity.

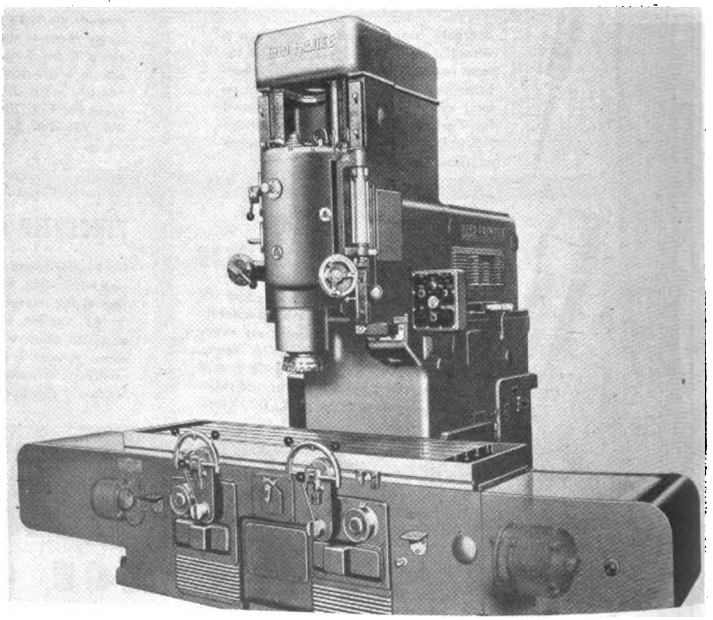
Milling Machine with Built-in Electronic Control

ELECTRONIC FEED drive for table, cross-slide, and vertical slide (spindle head), is a built-in feature of a new Reed-Prentice vertical milling machine. A centralized pushbutton control station contains all the controlling means of spindle start, stop and jog pushbuttons, dials for feed rate control, pushbutton to energize the electronic units, emergency master stop pushbutton and a function selector switch.

The large photo shows two centralized operating levers, in easy reach of the operator. Facing the machine, the group of controls on the right is for the table and the controls on the left for the slides. Each set consists of an airplane-type half-handwheel and a ball grip lever. This gives an infinitely variable feed rate in either direction. The further the handwheel is moved from center or neutral position, the higher the feed rate becomes. Similar to a servo control, this arrangement allows the operator to move the table or slides with practically no effort. The 5-position grip levers provide feed and rapid traverse in either direction. The feed rate is constant, preselected and controlled by the position of potentiometers located on the push-button station.

The operator can easily set the feed rate by simply adjusting the potentiometer knobs. This enables him to find the most efficient feed while the cutter is in action.

The table, cross-slide, and verti-



Reed-Prentice vertical milling machine with built-in electronic feed drive. Two electronic units control three motors; one is for the table motor, while the other unit can be switched from the cross-slide to the vertical slide when desired

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cal slide (spindle head) are driven by three 1½-hp, d-c motors with electronic control to provide infinitely variable feed rates. The range of the drives is from less than ½ inch to over 25 inches per minute, which corresponds to a ratio of 50:1 or more. The electronic units provide full-wave rectification, armature control for motor speed below 1330 rpm and field control for motor speed above 1330 rpm, reversing, overload and undervoltage protection, armature voltage drop compensation to maintain speed within close limits regardless of load fluctuation, and dynamic brake stop from any speed to prevent coasting.

There are two electronic units for the control of the three motors —one unit for the table motor and the other one for the cross-slide and vertical slide (spindle head) motors. Shift of the latter unit from one motor to the other one is accomplished by means of a selector switch mounted on the pushbutton control station. The electronic units are mounted on a hinged panel and enclosed in a sheet-metal box of dust-tight type. A blower is mounted inside the box for continuous air circulation.

Panel of the centralized control station of the vertical milling machine. The metal case of this unit is dust-tight so a blower is used to circulate air within the box

Radio for Emergency Use in Mining Operation

IN THE COLORADO ROCKIES, Telluride Mines, Inc. operate two hydroelectric generating plants, which supply most of their power requirements. Instant dispatching between any hydro-power house and its water source six miles away is imperative. Telephone systems usually provide adequate communication but such systems have an inherent disadvantage; they can only operate when wires are intact.

Rock slides or snow avalanches 30 feet high sometimes rip out entire sections of telephone line. The situation is further aggravated by the fact that Telluride's Blue Lake Reservoir lies at 12,200 feet in the San Miguel Range. Tapping the bottom is a 1,610-foot tunnel thru solid rock. From here a 2-mile welded steel penstock drops to the first power house where the water pressure is 800 lb per square inch. The average annual snowfall at Blue Lake is 45 feet, making regular winter inspection patrol impossible. Because of the high pressure in the penstock, leaks are cut out and enlarged as though an acetylene torch had been on the job, unless the inlet water valve at Blue Lake is quickly turned off. Otherwise the penstock may be damaged and the reservoir dissipated.

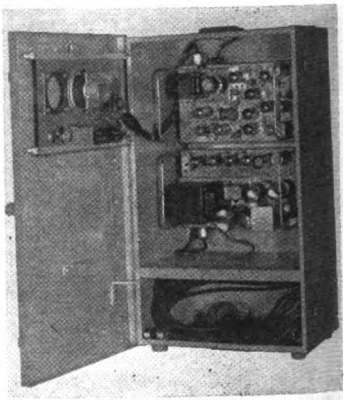
Use for Radio

Tests with General Electric equipment proved to the mine operators that two-way f-m radio to supplement the telephone facilities would provide emergency protection.

Station W2XCI was hauled by pack horse to Blue Lake at 12,200 feet elevation. W2XCH was left in its own station wagon to operate on the floor of Pandora Basin at Telluride, Colorado. Both W2XCI and W2XCH operate on an assigned experimental channel of 35.46 Mc with 60 watts of carrier power. These were the same veteran sets used successfully in tests conducted by GE for the Denver & Rio Grande Western Railroad.

In the Telluride demonstration, a severe thunder storm, followed by a Rocky Mountain blizzard, occurred during the tests. Reception was clear and strong and no lightning interference or snow static came thru the speakers. The line of sight discrepancy between the station wagon (9,020 feet) and W2XCI at Blue Lake (12,200 feet) was about 2,500 feet due to intervening mountains. This proved no barrier to successful communication because of a slight bending and multiple reflection of the f-m waves. Radio communication was proved practical—even in rugged mountain terrain.

Dashboard controls of the two-way f-m installation in the station wagon which operated on the floor of Pandora Basin, Colorado. Fred Deetken, G-E electronics engineer, checks reception



At the Telluride Mines, General Electric f-m equipment was used for communicating between a hydroelectric generating plant and its water source six miles away. A 60-w transmitter of the type used in the experiments is shown above

Increased Speed for Electronic Recorders

INCREASED INDUSTRIAL USE of electronic recorders has been made possible by stepping up chart speeds of Electronik pyro-potentiometers. The standard speed electronic recorders, single or multiple point

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—by the makers of Lindsay Structure

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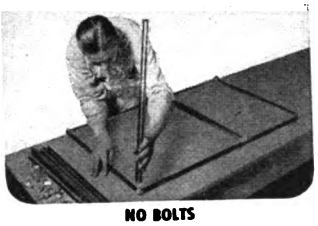
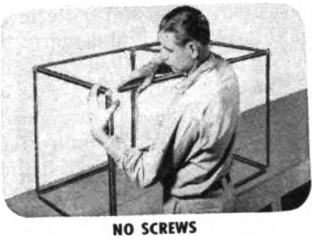
SL consists of only three basic parts—framing, panel sheets, and fittings. Once snapped together, they form a rigid, permanent construction. No bolts, screws, trimming, fitting, welding, or riveting are necessary for SL's assembly—making it excellent for line production.

Available in 24- and 26-gauge steel and in 61ST aluminum, SL will soon be obtainable in copper and other alloys as well. Adaptable to any conventional design, SL readily incorporates openings, louvers, doors, and similar construction details. The sturdy framing supports shelving, hooks, machinery, and equipment without requiring additional struts or braces, and proves ideal for cabinets and housings for electrical and electronic apparatus. Write for information. **Lindsay and Lindsay, 222-D W. Adams St., Chicago 6, Illinois; 60 E. 42nd St., New York 17, New York; Lindsay Structure (Canada) Ltd., Dominion Square Bldg., Montreal.**

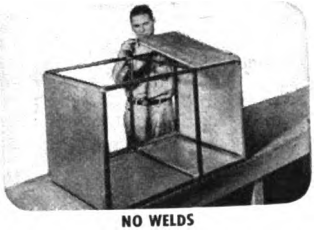


NO BOLTS



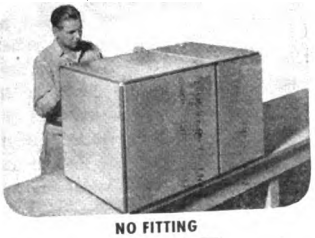
NO SCREWS

NO RIVETS



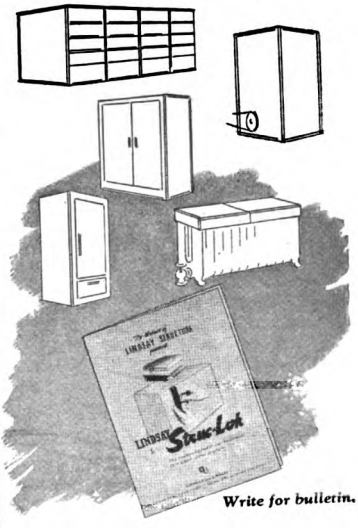
NO WELDS

NO TRIMMING



NO FITTING

Basic Parts for SL



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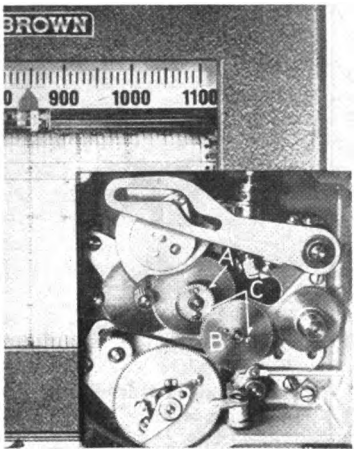
models, incorporate gear changes for speeds of 5, 10, 15 and 20 inches an hour, it has been announced by Brown Instrument Company.

As shown in the accompanying illustration, the gears are changed by removing screw *C* from gears



Gears A and B, shown above, can be replaced by new gears for faster operation of the Brown recorder

A and *B* and by lifting the gears from the assembly. The new speed gears are then installed and screw *C* is replaced.

Fast speed electronic models, single or multiple point, will have internally mounted gears that provide speeds of 10, 20, 30 and 40 inches an hour.

Penetron Measures Thickness and Density with Gamma Rays

SECRECY has recently been lifted by the government on a new device utilizing electronic and radioactivity principles for the measurement of thickness of solids, metallic or non-metallic, and for determining liquid level and liquid density. This device, called the Penetron, need only be held against one side of a wall to obtain an accurate measure of wall thickness or an indication of the nature and level of the liquid or material on the other side of the wall.

Principle of Operation

In operation the instrument bombards material with gamma rays which are derived from a needle containing one milligram of radium in the form of a commercially available salt. These gamma rays travel with the velocity of light and are, in fact, radiant energy. They are not deflected by magnetic or electrical fields. Some of these rays are back-scattered by the electrons of the atoms in the material being inspected, so that they emerge from the material on the same side as they entered. The intensity of the back-scattered radiation increases as a direct function of the thickness of the material at the spot being measured. By measuring the intensity of this back-scattered radiation, the thickness of the material, whether it be steel, aluminum, plastic, brass, wood, or any other substance, can be obtained with extreme accuracy. By the same means, liquid levels and liquid densities are also obtained.

The radium source is surrounded with a shield containing a window which directs the beam of gamma rays in the desired direction. The thickness and design of the shield were arrived at after a careful study of the allowable dosages of gamma rays to which the average individual may be exposed without any physiological effects.

In order that the measurement of back-scattered radiation may be made with a high degree of accuracy, it is necessary to set up the source of radiation, the wall and the detector in accordance with a pre-determined geometric arrangement. A metal shield is positioned between the radioactive source and the radiation detector to prevent direct radiation from entering the detector.

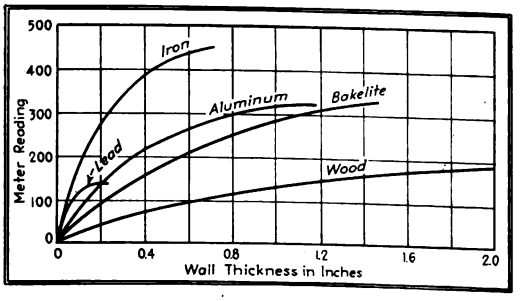
The radiation picked up by the detector creates current discharges which are amplified and integrated to produce a direct current. The amount of current produced is measured by a microammeter.

Calibration Curves

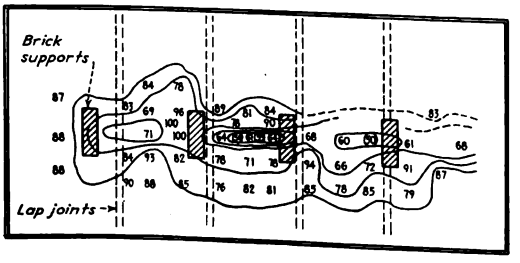
In order to convert the reading of the microammeter into wall thickness in inches, the instrument is calibrated on specimens of tubing and flat plates having known wall thicknesses. Because the geometrical relationship between the measuring head and the wall changes with the curvature of the wall, it is to be expected that the calibration curves for a wall of a given composition will vary depending on the diameter or curvature of the wall or vessel being measured, and on whether the measurements of curved surfaces are made from the outside or from the inside.

Calibration curves have to be established only once and are furnished with the instrument. The curves are not affected by small changes in the chemical composition of the material comprising the wall. For example, the calibration curves for iron also apply to alloyed steels.

Wall thickness measurements can



Typical calibration curves for flat plates of various materials. The maximum measurable thickness for a given material is that at which further increases in thickness do not affect the meter reading



Wall thickness measurements (in hundredths of an inch) made from the outside of a large surge drum, with contour lines drawn through points of equal thickness. Smallest contour loops show severe erosion of wall material

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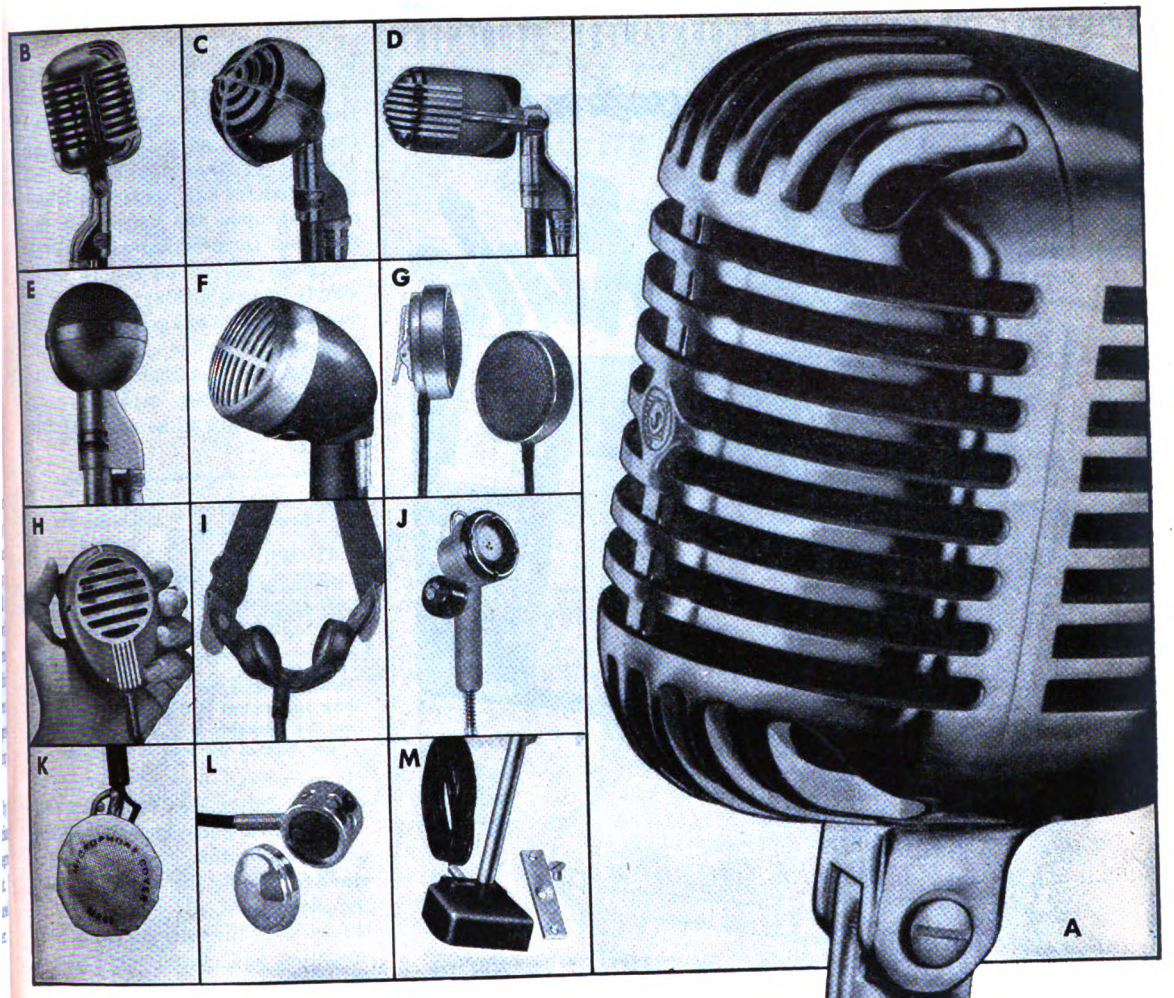

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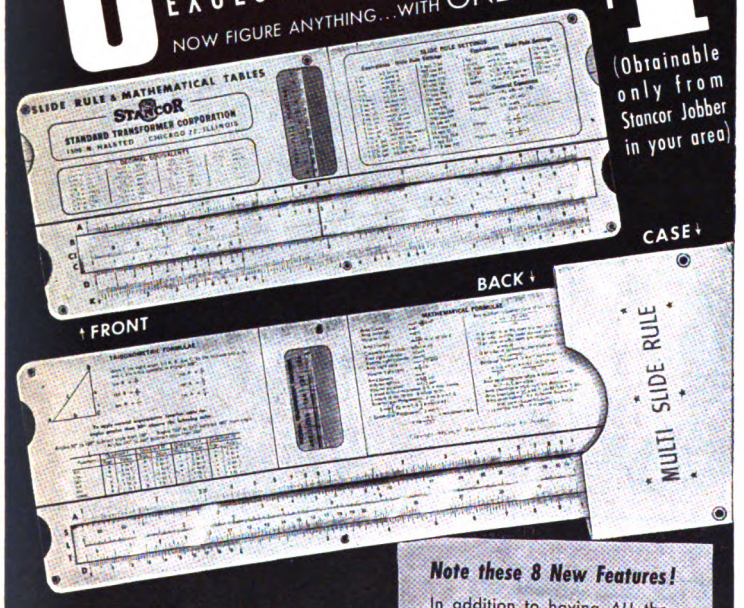

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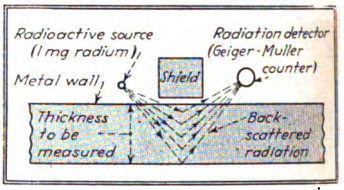
be made on pipes or vessels which contain fluids, provided a correction is made to take into account the influence of the fluid on the reading of the instrument. The magnitude of this correction is dependent upon the density of the fluid, but for practical purposes the necessary correction can be made simply by establishing a calibration curve for pipes of known wall thickness filled with the same fluid.

With any electronic equipment, failures of tubes, capacitors and other parts are to be expected. In order to detect such failures, a set of concentric half-round steel shells and a calibration curve for these standard shells are supplied with the instrument. By measuring the thickness of the standard shells, the operation and overall performance of the instrument may be checked quickly at any time. Equipment failures of any type will be reflected by a deviation from the standard calibration curve.



Operating principle of the Penetron, a new radioactive instrument for measuring the thickness of a wall when only one side of the wall is accessible

Measuring Limits and Accuracy

In general, calibration curves for the instrument have a rather steep slope for the smaller wall thicknesses but tend to flatten out with increasing wall thickness. The thickness at which flattening of the curve starts is the limit for accurate measurements. The accompanying calibration curves show that the Penetron can be used for measuring iron or steel walls up to approximately 0.75 inch thickness. For other materials the limit is different, being approximately one inch for aluminum. This limitation is due to the fact that the penetrative power of deflected or scattered gamma rays is less than that of the primary rays and rays which are deflected beyond a certain depth are

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G-E time meters, Type KT, keep an accurate record of hours of tube use; tell you when it is time to replace tubes.

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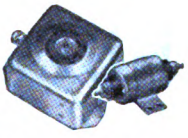
How to *Kill radio noise*



Particularly effective in the band frequencies from 200 kilocycles to 20 megacycles, G-E pi-type filters are especially suited to suppressing radio noises caused by generators, dynamotors, inverters, and similar equipment used on aircraft. Rated 25, 100, and 200 amperes at 50 volts, d-c, they comply with the requirements of U.S.A.A.F. Specifications No. 32331-A.

Where economy calls for lower-cost filtering, the G-E thru-stud capacitor provides effective filtering from 200 kilocycles up to 38 megacycles with attenuation characteristics far superior to those of conventional capacitors. Weighs only 4½ ounces. Write for Bulletins GEA-4098A and GEA-4308.

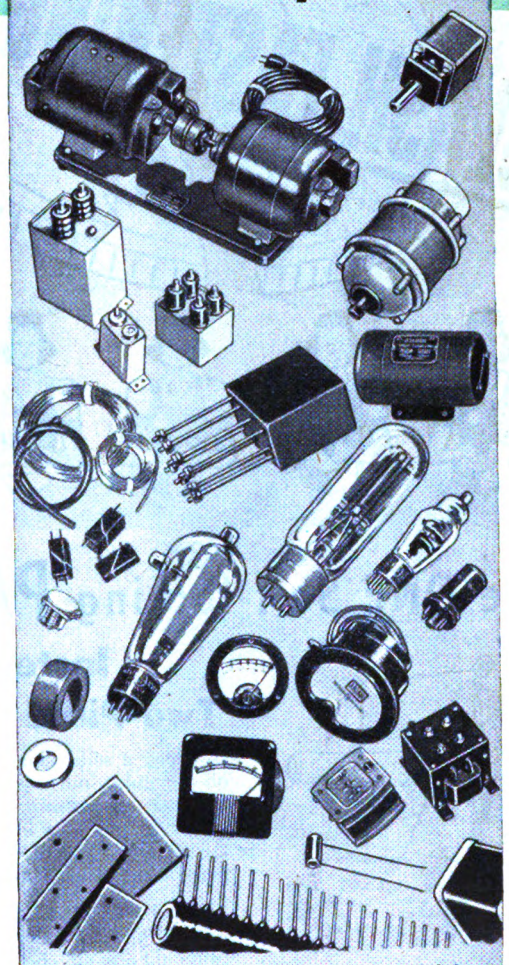
Just *"8 bits" big*

These new 1½-inch G-E panel instruments, just the diameter of a silver dollar, are less than an inch deep and weigh only three ounces. Yet they incorporate all the desirable features associated with the unique G-E internal-pivot construction, and are accurate to within plus or minus 2 per cent.

Fast response and high resistance to vibration are two of the advantages of this instrument's high torque and light-weight moving element, while good damping makes reading both easy and accurate.

Supplied for direct-current, radio-frequency, and audio-frequency service, in both watertight and conventional cases. Write for Bulletin GEA-4380.

Timely Highlights on G-E Components



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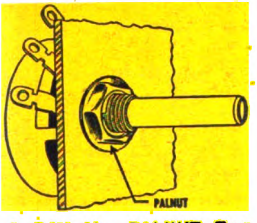

A Self-locking PALNUT Type WT replaced more expensive jam nut and lockwasher on this volume control, saving in cost of material and labor.

By using a self-locking PALNUT in place of a regular nut and lockwasher, you cut the cost of fastenings in half and reduce assembly time 50%. At the same time, the PALNUT double locking action* keeps parts tight under vibration.

Self-locking PALNUTS are especially adapted to fast moving assembly lines, because they apply speedily with power drivers or Yankee drivers. Fit into same space as hex nuts. PALNUTS are single thread, spring tempered steel locknuts, requiring only 3 screw threads. Very low in cost. Available in a wide range of types, sizes, finishes and materials.

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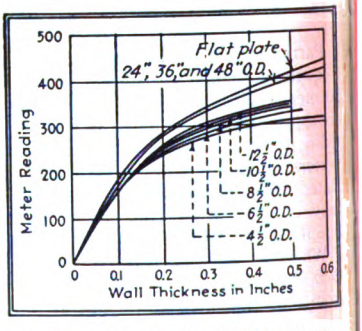
The Palnut Co. 77 Cordier St., Irvington 11, N.J.

Self-Locking PALNUTS

completely absorbed before reaching the surface as back-scattered radiation. Only thin sheets of lead, up to about 0.1 inch thick, can be measured accurately because the high atomic number of lead approaches that of radium and entirely different effects take place.

The accuracy of the instrument has been established by conducting hundreds of experiments with specimens of unknown wall thickness. After determining the thickness by means of the Penetron, the specimens were drilled and calipered mechanically. By this method the Penetron has been established to have an accuracy within plus or minus 3 percent.

The Penetron measures the average thickness over an area of approximately one square inch. For this reason, it cannot be used for the detection of cracks, pin-holes, or pin-hole type corrosion, nor can



Calibration curves for outside measurements on iron plates and iron tubing

it differentiate between the component layers of laminated construction. It measures the total thickness or volume and not the thickness of any one layer. If, however, a laminated wall is composed of, say, two layers of different materials, the Penetron can be used to measure the thickness of either layer provided the thickness of the other layer is known. In this case the thickness of the unknown layer is determined as the difference between the total thickness and the thickness of the known layer.

150 Measurements per Day

The individual pulses of current created in the detector do not follow each other at regular intervals because the rate of emission of

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and the progeny of the "blending" are happily at work, promoting efficiency throughout the electrical industry where prior to the "marriage" let-downs frequently occurred.

Mica, as is well known, while one of the most satisfactory materials for electrical insulation because of its high dielectric, high compression strength and high heat resistance, is weak mechanically since it must be used in the form of built-up splittings of very fine film.

In order to take advantage of the insulating values of Mica and to overcome its mechanical deficiences a reinforcement was found to be necessary. Fiberglas, with its great mechanical strength, its high temperature, dielectric and excellent moisture resistance proved to be the ideal reinforcement for Mica Splittings.

The products of this union—Fiberglas-Mica-Combinations — have all the desired qualities to combat severe service hazards; great mechanical strength, non-stretch, no need to varnish, available in any thickness from .010 to 35 mils, resist temperatures beyond 150° C., and extremely high dielectric.

Write for Bulletin HC 2-1, it tells the entire story of Fiberglas-Mica-Combinations . . . and for Quick Deliveries *PHONE—WIRE—or—WRITE*

MFG-0 made with 3-mil Fiberglas on only one surface of the Mica. Available in overall thicknesses ranging from 10 to 20 mils inclusive . . . **MFG-1** made with 3-mil Fiberglas on both surfaces of the Mica. Available in overall thicknesses ranging from 10 to 25 mils inclusive . . . **MFG-2** made with 3-mil Fiberglas on one surface of the Mica, but with 12-mil Fiberglas on the other side. Available in overall thicknesses ranging from 20 to 35 mils inclusive . . . . **MFG-3** made by bonding 1-mil paper to one surface of the Mica and 3-mil Fiberglas to the other. Available in two overall thicknesses—6 and 8 mils approximately . . . **MFG-4** made with one surface of 1-mil paper and with 7-mil Fiberglas on the opposite side of the Mica. Available in overall thicknesses of 10, 12 and 15 mils . . . **MFG-5** made with 3-mil Fiberglas on one surface of the Mica, but with 15-mil Fiberglas on the other side. Available in thicknesses ranging from 25 to 35 mils, inclusive.

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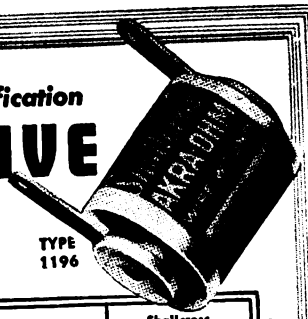
Joint Army-Navy R93 Specification

COMPARATIVE DATA



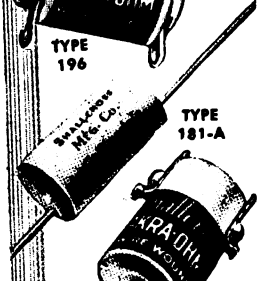
TYPE 1196

JAN Style Numbers RB	JAN Power Ratings Watts	Shallcross Type Numbers	Shallcross Power Ratings Watts
RB10	0.25	173	0.25
		176*	0.25
RB11	1/3	183	0.5
		183-A	0.5
		186*	0.5
RB12	0.5	193*	1.0
RB13	0.5	196	1.0
		1196**	1.0
RB14	1.0	116	2.0
	1.0	1110**	2.0
RB20	0.75	100	1.0
RB21	Suggest JAN 20 or JAN 22		
RB22	1.5	110	2.0
RB40	0.4	120	0.25
RB41	0.5	140	0.5
RB42	0.6	160	1.0
RB51	0.25	181-A	0.5

NOTE: * Indicates Maximum JAN Dimensions.
** Indicates Hermetically Sealed Resistor.

TYPE 100

TYPE 196



TYPE 181-A

TYPE 140

TYPE 173

JAN R93 and SHALLCROSS Akra-Ohm Accurate Fixed Wire Wound RESISTOR TYPES

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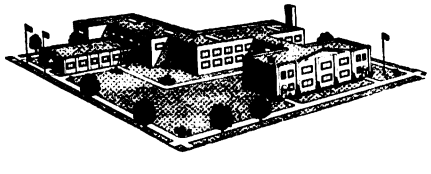

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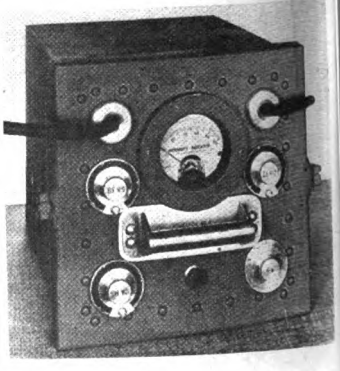
DEPT. E-85, COLLINGDALE, PA.

gamma rays by radium is quite irregular. The emission follows certain statistical laws and fluctuates around an average value. The accuracy with which this average value can be determined experimentally increases as the time of observation is increased. Considerations along these lines lead to the establishment of a minimum time for any measurement in radioactivity in order to achieve a required accuracy. In the case of the Penetron, the minimum time for each reading is 25 seconds.

Allowing for moving the instrument, set-up time and recording of results, in actual field work it has been found that it is easily possible to make measurements at 150 or more points during a working day.

Determination of Liquid Level

The instrument accomplishes its various functions by accurately measuring the amount of back-scattered radiation. If the head of the Penetron is placed on the wall of a vessel partially filled with liquid



Control box of latest industrial version of the Penetron. The seven-wire cable at the left goes to the detector head, and the other cable goes to any 115-volt, 60-cycle power source

and above the level of the liquid, the amount of back-scattered radiation will be due entirely to the wall of the vessel, since the density of the air or vapor in the vessel is substantially negligible by comparison with the density of the material comprising the wall.

If the head is moved down along the wall of the vessel the reading of the instrument will remain constant until it reaches a point oppo-

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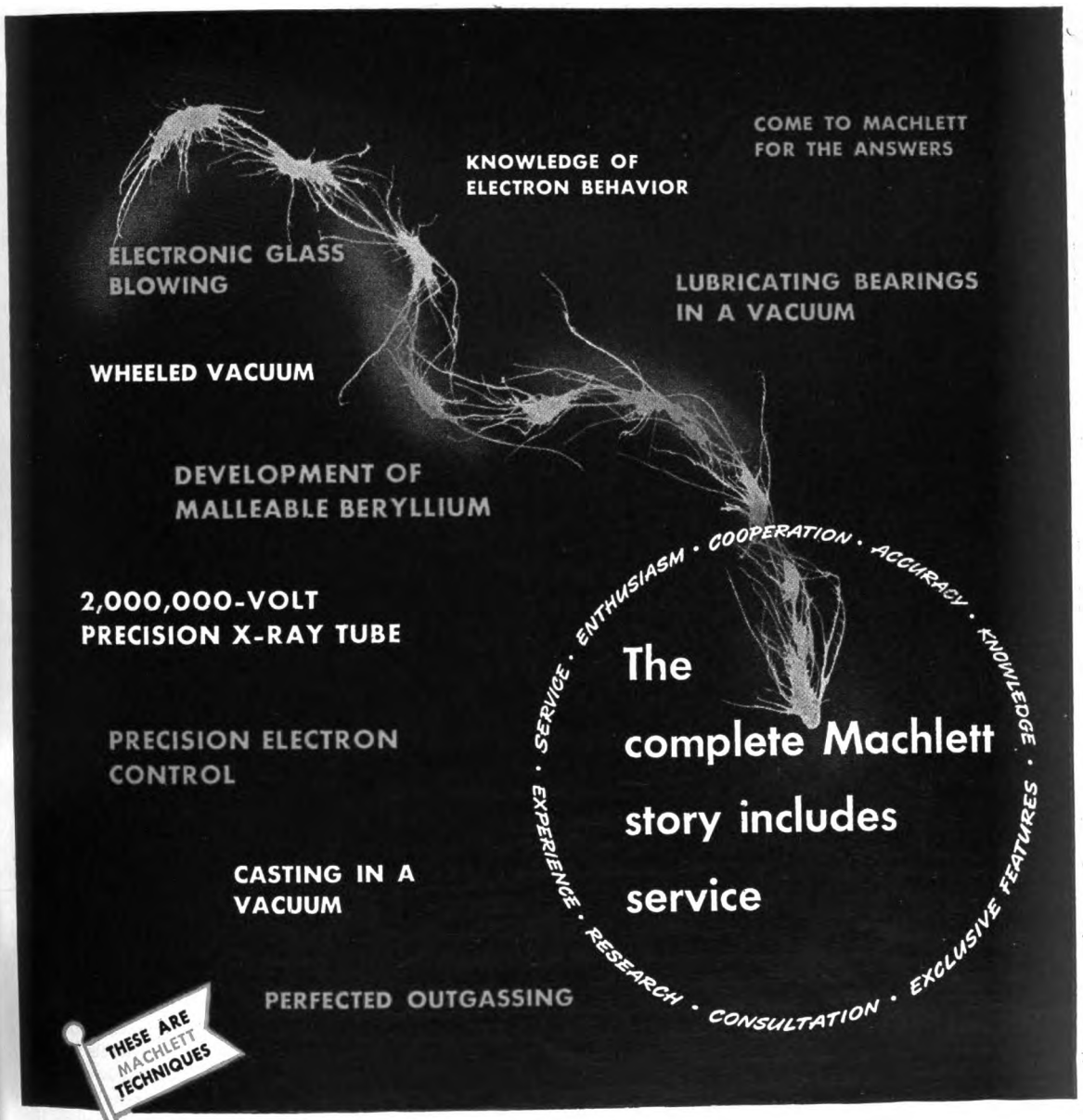

The above ten Machlett techniques reflect only a part of one side of this organization — that of technical capability.

It takes much more than even the highest techniques to make a business great. There is also required a thorough knowledge of customers' requirements, and that conscientious, painstaking, continuing meeting of them called "service."

Just as there is the most intimate relationship between an electron tube and the equipment with which it is connected, so there is a close and constant contact with our customers. With them we are never in competition, and thus we may be, and often are, called upon to do design and development work, to live with tube and equipment problems, and cooperate in solving them. We often follow through all the way to the ultimate users, to make certain of their satisfaction and see that conditions of use are such as to assure optimum results and economy. It is a long-established Machlett practice not merely to accept but to seek out every opportunity to serve. Thus, Machlett customers obtain much more than the best possible tubes.

When you need a medical or industrial X-ray tube, or a radio or industrial oscillator, amplifier or rectifier, it will pay you to choose a Machlett. Write for information as to available types, identifying the associated equipment and nature of use. Machlett Laboratories, Inc., Springdale, Connecticut.

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES ITS 18 YEARS OF ELECTRON-TUBE EXPERIENCE

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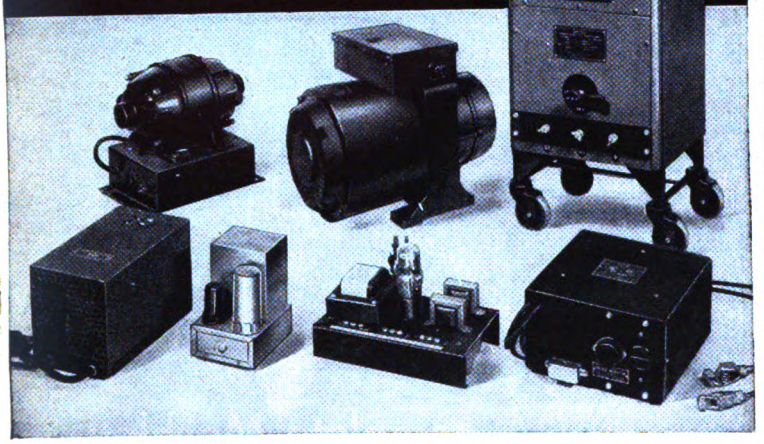

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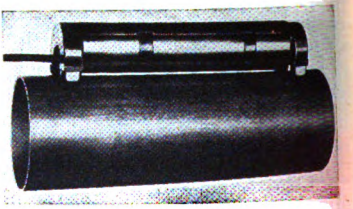
site the level of the liquid in the container. At this point, the meter of the instrument will indicate an increase in the amount of back-scattered radiation, due to the fact that the radiation passing through the wall is scattered not only by the wall but also by the liquid in the vessel. By noting the point on the wall of the vessel at which an increase in the reading of the instrument is obtained, it is possible to locate the level of the liquid quite accurately. Likewise, the interface between two fluids of different densities can be located easily and accurately from the outside of a container without actual access to the interior of the container.

By proper instrumentation, the Penetron may be adapted to control as well as to locate liquid levels. In addition, a continuous record of the location of the levels may be obtained by employing a recording device. Liquid level measurements which may be made with the Penetron include gaging liquids in storage tanks, gaging liquefied gases in cylinders, controlling levels in process units such as the solvent-oil interface in a solvent refining tower, and determining and controlling the catalyst level in catalyzed chemical reactions.



Measuring head in magnet-type holder designed for use on ferrous tubing

Determination of Specific Gravity of Fluids

All penetrating radiation is to a certain extent scattered or diffusely reflected by the material it traverses and the degree of scattering is a function of the number of electrons encountered by the penetrating rays in their passage through the material. Since the total number of electrons present in a unit volume of any substance is closely related to the density of that substance, it is apparent that the

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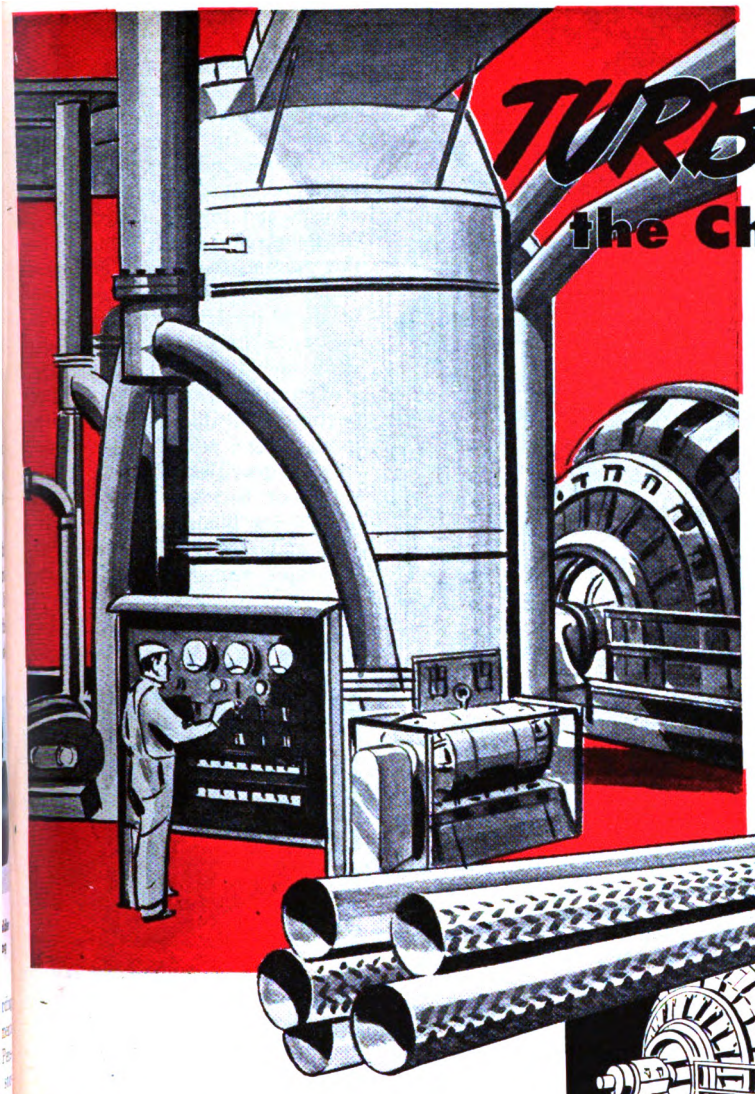
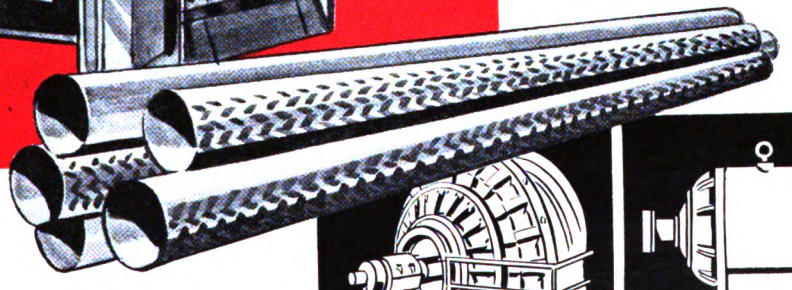
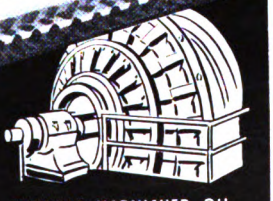
TURBO majors in the Chemical field

...and sets new standards for electrical insulation efficiency for all industries!

Chemical plants—tough proving grounds for any type of electrical insulation—involve severe deteriorating influences; acids, alkalis, solvents, corrosive fumes, vapor, moisture and humidity are usually encountered. Not to be outdone, wide temperature fluctuations add materially to the hazards of insulation, too.





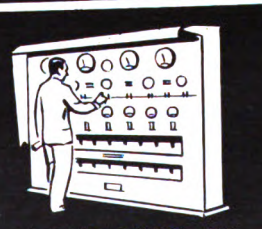


FLEXIBLE VARNISHED OIL TUBING: This product finds application where immunity to corrosive fumes, acids, alkalis and solvents is essential. It is impervious to moisture and non-hygroscopic. An important insulation for chemical installation.

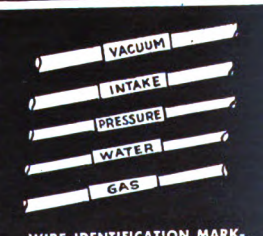
VARNISHED GLASS TUBING: An extensively used sleeving, resistant to high temperature. Recommended for heavy duty in confined areas where ventilation is at a minimum. Suitable for enclosed motors and wiring subjected to high heat.

TURBO Sleevings — diversified in characteristics — provide solutions to these adversities. They are available in four types to meet specific operating conditions—Extruded Tubing for immunity to sub-zero temperatures; Varnished Glass Tubing for resistance to high heat; Flexible Varnished Oil Tubing for resistance to chemicals, moisture, etc. All feature perfect concentricity and smooth bore for rapid and easy installation.

TURBO Wire Markers, too, are supplied in all sizes, colors and markings. They are easily applied, permanent and simplify maintenance and repair. Write today for the free TURBO Sample Board; specimens and sizes of each type tubing are included.



EXTRUDED TUBING: This smooth, wall tubing withstands the rigors of severe low temperatures. This immunity to embrittlement at sub-zero cold permits wiring runs adjacent to low temperature equipment, piping, etc. with assurance of dependability.



WIRE IDENTIFICATION MARKERS: Now available in two types —sleeve and tab Furnished in any color and marking, they reduce identification and tracing of piping, conduits and cables to an accurate split second procedure.

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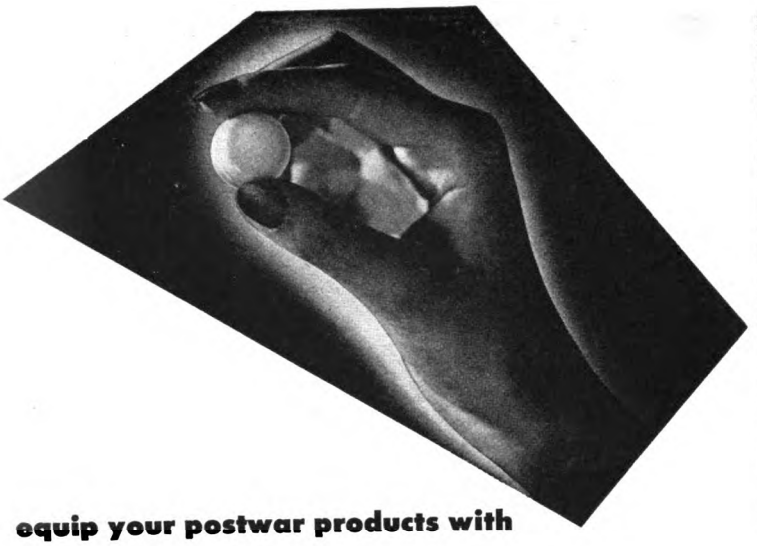

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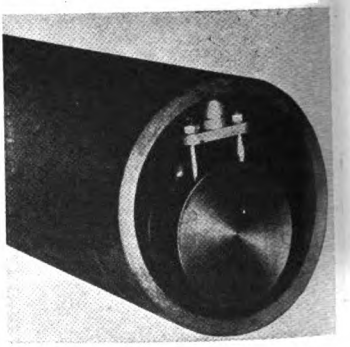
amount of scattering per unit volume is largely dependent upon the density of the material. Therefore, as the density of the material increases the amount of back-scattered radiation detected also increases and for practical purposes the Penetron measures density. For this reason, the density of a fluid inside of a container may be determined directly without access to the fluid itself. In experimental work employing a Penetron situated on the outer wall of a container having a wall thickness of 0.3 inch, it was found possible to check the specific gravities of fluids having values of between 10 deg Baume and 75 deg Baume with a high degree of accuracy. This measuring technique can be used advantageously only for determining specific gravity of liquids in tankage, routing the flow of oil in pipe lines, control of blending operations in which two materials of different densities are mixed, determination and control of proportions of reactants in chemical processes, and in numerous other applications where it is desired to determine the density of a substance without the necessity of sampling or without actual access to the material.



Measuring head used with hydraulic-type holder for inside measurements of tubing, made when the outside is inaccessible

Description of Parts

The Penetron consists of two main parts—the head and the control box. The head contains the radiation source, the detector, a shield between the two and a three-stage preamplifier. It weighs about 7 lb and is connected by a seven-wire

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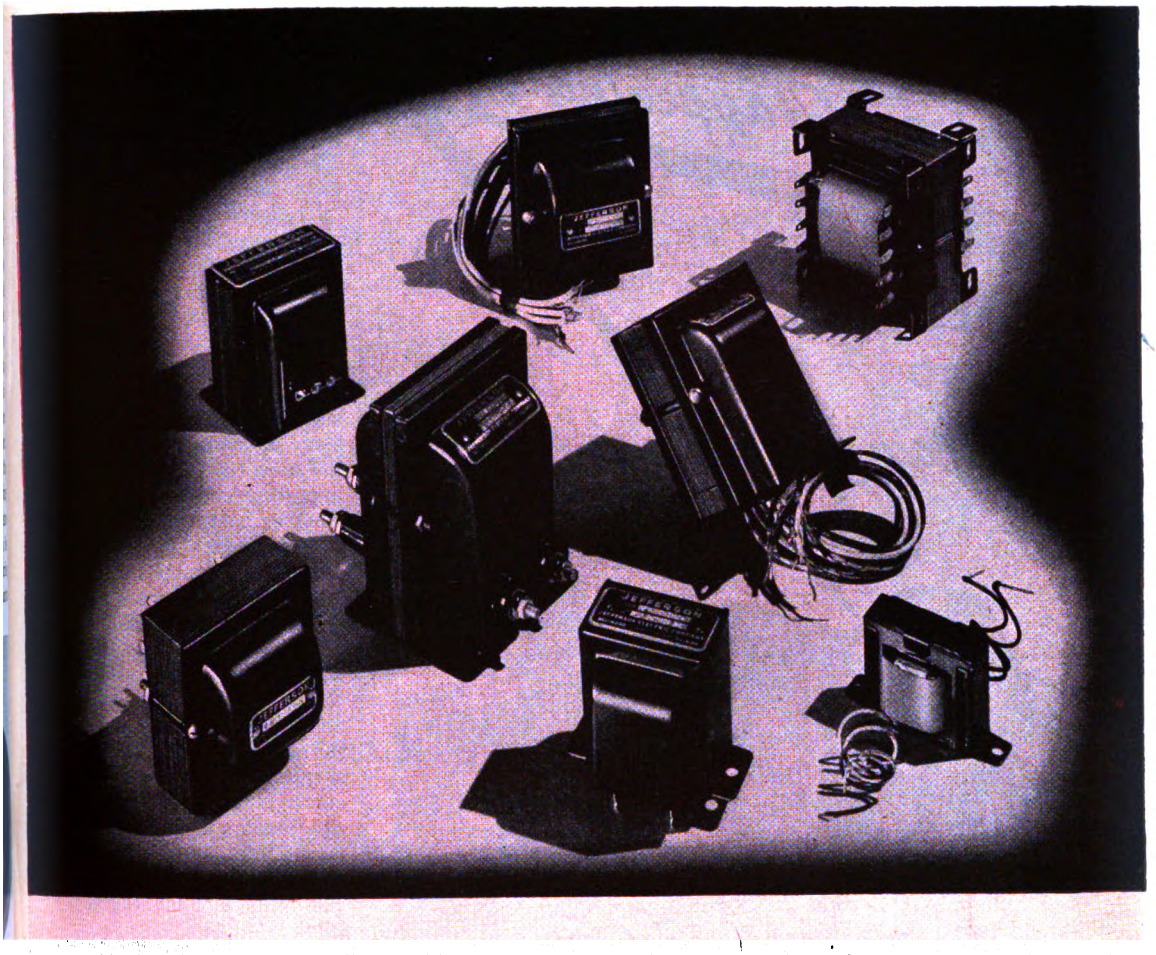

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unshielded 75-foot cable to the control box which contains the measuring circuit and the power supply. The head is completely sealed in its metal housing, as required for use in refineries and other locations where explosive hydrocarbons may react to sparks.

The measuring head proper consists of steel tubing 2½ inches in diameter and 13 inches in length, which can be inserted in various holders. One holder is equipped with two permanent magnets which serve as supporting points and at the same time hold the head firmly in position on iron or steel surfaces. Another holder is provided with a chain clamping device for use on nonmagnetic materials.

If measurements are to be taken on the inside of tubings a pneumatic type holder is used. It is equipped with two pistons which can be moved by compressed air or fluid pressure. These pistons press the head against the inside of a pipe or tube in any desired direction. The clamp is maneuvered with extension handles, and measurements can be made at any desired point and at any desired angle along the inside of tubes of any length.

Smaller Unit

Another and smaller measuring head utilizes the principle that metal inserted between the source and the detector causes a decrease in the meter reading. The gamma rays are directed tangentially across the tubing. If the wall of the tubing is thinner at some point, the amount of absorbing material is less and the meter reading changes accordingly. This technique works regardless of the curvature of the pipe, and is advantageous in crowded locations like boilers, where some tubes cannot be reached with the more bulky measuring heads. Only one tube is incorporated in this small head, the other two being in a cylinder inserted in the connecting cable a few feet from the head.

The present instrument employs only one milligram of radium as the gamma ray source, as contrasted to 25 milligrams required in earlier models. The radium is supported at the apex of a cone-shaped ele-

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AUTOMATIC CONTROLS Governed by Temperature

Neither planes, tanks, ships nor guns could operate efficiently without scores of precision built, automatic controls. And wherever temperature is a factor, Chace Thermostatic Bimetal is constantly being called upon by the control builder to serve as the actuating element for his device, for indication, control, or both.

These war-time applications cover a temperature range from −100 to +1000° F. And at any pre-determined point within that range, Chace bimetal may be called upon to give the impetus to start, or to stop, some vital function. That is, it must convert temperature into action; automatically, instantly, and without fail.

Similarly, in the home, appliance manufacturers utilize the known properties of specific types of Chace bimetal to convert temperature into action in devices ranging from toasters to furnace controls, or to refrigerator motor protection.

There are thirty-five types of Chace Thermostatic Bimetal, each of which offers specific advantages to control builders. Sold in sheets, strips, and finished forms.

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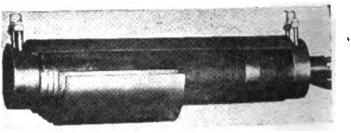
ment, the base of which is attached directly to the housing of the detector. This cone serves to shield the detector from direct radiation emanating from the radium.

The life of the radium source is unlimited. It takes 1690 years to reduce the quantity of gamma ray emission to half of its original value.

Two kinds of detectors for gamma rays are known—the ionization chamber and the Geiger-Muller type of counter. In the Penetron, a high-efficiency Geiger-Muller counter of improved design is employed. The counter is contained in a housing which is fitted longitudinally into the head and is



Measuring head in hydraulic-type holder, showing concentric steel shells used for routine calibration and check of performance

shielded in such a way that it is open to radiation coming from the wall to be measured. Back-scattered radiation enters the counter and sets off current discharges or pulses. The rate at which these pulses of current are generated is proportional to the intensity of the radiation entering the counter, which in turn is a function of the wall thickness.

Pulse Amplifier

The pulses of current produced in the detector are extremely small. Since these pulses must be transmitted through 75 feet of cable it is necessary that they be increased in magnitude sufficiently to be distinct when they are picked up at the measuring circuit in the control box. This function is performed by the three-stage preamplifier located in the head of the instrument.

The pulses of current are further amplified in the control box and by means of a special electrical circuit are integrated to produce a direct current, the magnitude of which is proportional to the number of current pulses created per unit of time in the detector by the back-scattered radiation. The current

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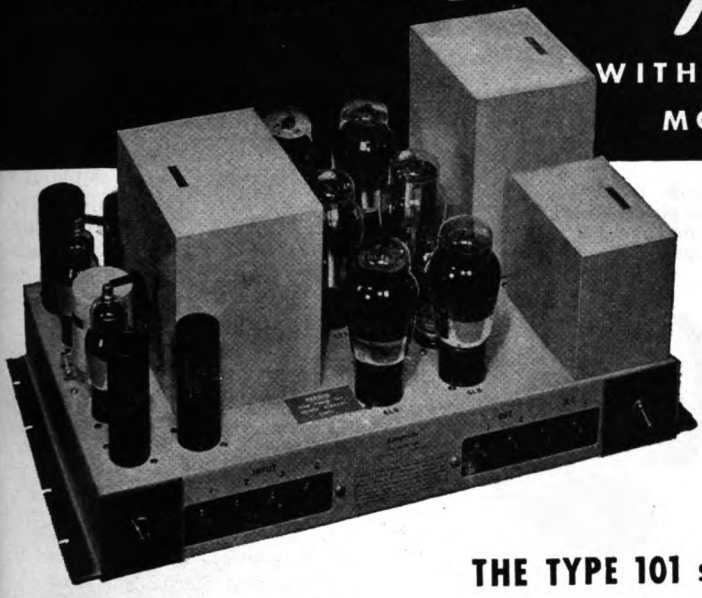
101 SERIES *Amplifiers*

WITH RACK PANEL OR WALL MOUNTING ACCESSORIES



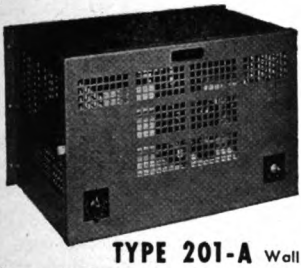
Input impedance 600 ohms and bridging. Gain 600 ohm input 61 db., bridging input 46 db. Frequency response 30 to 16,000 c.p.s. either input—600 ohm output ±.5 db., 30 ohm output ±1 db. Power output—production run average: +47 V.U. with less than 3% RMS harmonic content.

THE TYPE 101 Series Amplifiers are the results of twenty years' experience in the sound engineering field. They are identical with the exception of the output coil.

Type 101-A has output impedance adjustments to match loads from 1 to 1000 ohms and possesses excellent low frequency waveform at high output levels.

Type 101-B with a single nominal 6 ohm output is intended for use with wide range loudspeakers representing an 8 to 16 ohm load. Its output coil with a single secondary provides improved efficiency and even better waveform at high levels of low frequencies.

Type 101-C answers the demand for a good amplifier at lower cost. This lower cost is obtained by the use of a less expensive output coil with the only change being that the low frequency waveform is not as good as the A or B types but is equal to or better than any contemporary commercial amplifier. Output impedance is adjustable to loads of 1 to 1000 ohms.



TYPE 201-A Wall Mounting Cabinet permits universal installation of 101 Series Amplifiers to any flat surface. Well ventilated and designed for maximum accessibility for servicing and convenience of installation. Standard aluminum gray finish.

TYPE 7-A Modification Group permits 101 Series Amplifiers to mount on standard 19" telephone relay racks. Occupies 12¼" rack space. Allows servicing from front of rack. Standard aluminum gray finish.

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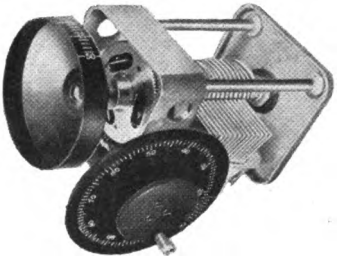
PRECISION CAPACITORS by CARDWELL

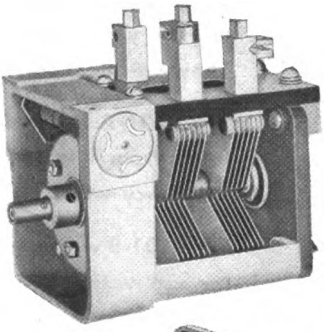
An outstanding Cardwell wartime achievement is the development of precision worm drive capacitors, of maximum stability and resettability, for use in various types of frequency meters.

Although not standard catalog items, the three types illustrated are typical of the possible variations of this general design which is widely used in Cardwell instruments built for the Army and Navy. Perhaps one of them is the answer to your design needs for an S.L.F. type precision capacitor of highest quality.



PART No. 4.080
21-220 mmfd.;
airgap .030"

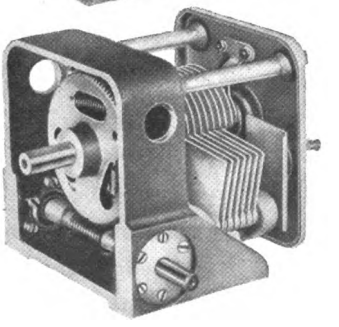
As used in S. C. Frequency Meter covering range of 125-20,000 KC, 125-250 KC low band fundamental, 2 MC-4 MC high band fundamental.



PART No. 4.400
8-130 mmfd. per section;
airgap .020"

Used in ATSC Frequency Meter covering fundamental range of 85-200 MC and to 1000 MC harmonically.

Four studs support special trimmer and compensator capacitors which are not shown.



PART No. 4.200
15-125 mmfd.;
airgap .027"

In another ATSC Frequency Meter, this condenser tunes the oscillator over fundamental range of 20-40 MC and to 250 MC harmonically. Has adjustable compensator and trimmer.

CARDWELL QUALITY PRODUCTS

CARDWELL CONDENSERS

THE ALLEN D. CARDWELL MANUFACTURING CORPORATION

81 PROSPECT STREET BROOKLYN 1, N. Y.

measured by means of a microammeter located on the face of the control box. The meter readings are readily converted to the wall thickness of the object being measured, by referring to the appropriate calibration curve.

The instrument is designed to operate from a 115-volt, 60-cycle a-c line. The total power consumption is approximately 100 watts.

Uses

Experimental work involving the substitution of a neutron source and detector for the gamma-ray source and detector has indicated that wall thicknesses up to four inches of steel can be measured with a high degree of accuracy.

In addition to liquid level and specific gravity applications, the various versions of the Penetron may be used for a wide variety of different purposes, including chemical process control and ship hull and boiler inspection.

The Penetron was perfected in the laboratories of the Texaco Development Corp., New York City. Dr. Gerhard Herzog directed research and development

Engineering Laboratories, Inc., Tulsa, Oklahoma, has been exclusively licensed for the sale and manufacture of the instrument. This company in 1937 developed radioactivity well logging, which discovers and records bypassed oil producing areas through steel well casing. The method utilizes neutron measurement which is somewhat similar to the Penetron method, and has been responsible for discovery of hundreds of producing wells.

• • •

Electrostatic Deposition of Phosphor Powders

THE CONVENTIONAL manufacturing process used in coating fluorescent tubing has been to suspend the phosphor powder in a solution which is allowed to flow through the glass tubing after it has been carefully washed. The tubing is then allowed to dry, after which it is baked to remove the liquid.

In an electrostatic method using the Westinghouse Precipitrons, the tubing is slipped over an ionizing wire and a high potential placed

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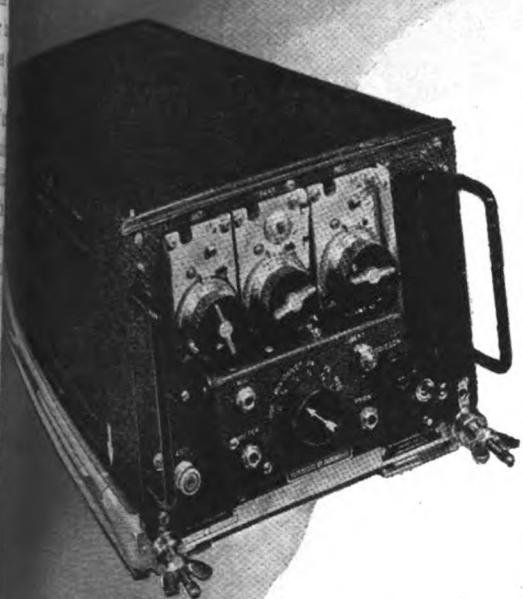
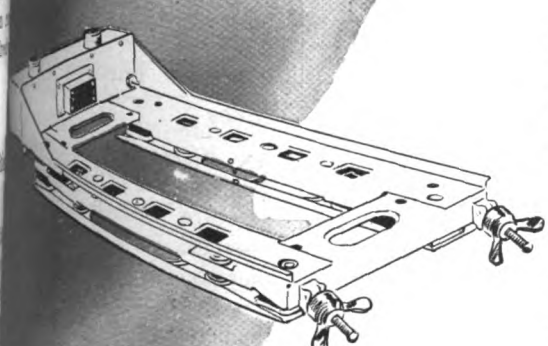
vibration IS destructive



The ARC-1, designed by Bell Telephone Laboratories, is manufactured by Western Electric Company. This Navy standard combination transmitter and receiver is not only used on all Navy fighter planes but also on battleships, carriers and submarines.



The Robinson Vibrashock suspension—Model W-386—supports all the ARC-1 Western Electric Transmitter Receivers. This is an example of the way in which the Vibrashock principle can be adapted to the form factor and space requirements of electronic equipments.

This is the reason why Robinson **Vibrashock*** suspensions are used for the important role of supporting the Western Electric ARC-1 Navy Transmitter Receiver, which is installed in all Navy fighter planes.

Robinson engineers have adapted **Vibrashock**, the new principle of vibration control, to dozens of different types of vitally important airborne equipment. All this equipment needed special protection from shock and vibration that was not attainable with conventional types of shock mounts.

Over 90% of all vibration throughout the aircraft operating range is effectively eliminated with Robinson Vibrashock. No other shock mount can offer so much in vibration absorption. This performance extends the service life of airborne equipment and drastically reduces maintenance and overhaul time and expense.

More and more manufacturers and users of airborne equipment are turning to Robinson for that engineering skill which is reflected in the important jobs Vibrashock is now performing.

Our services are available to aircraft, radio, and electronic manufacturers and users in connection with any mechanical or electronic equipment requiring protection from vibration and shock.

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The fine electronic instruments shown above are examples of the precision production that characterizes all ANDREW equipment. Designed and built by skilled engineers, ANDREW CO. electronic equipment is used the world over wherever specialized apparatus is needed.

1. **TYPE 40A PHASE METER**—This direct reading, precision instrument measures in degrees the phase angle between currents in radiating elements of a directional antenna system. It operates on a signal input of only 200 millivolts and may also be used for general laboratory work.

2. **TYPE 291 HF OSCILLATOR**—This portable battery operated oscillator is used for checking high frequency receivers, especially aircraft type. The frequency range is from 49 to 154 Mc. with modulation frequencies of 70, 90, 400, 1300 and 3000 cycles. This unit contains a collapsible whip antenna for checking receivers without direct connections, and provides 2 coaxial terminals for low and high level output.

3. **TYPE 708 REMOTE ANTENNA AMMETER**—This unit contains a diode rectifier with a DC micro-ammeter calibrated in RF amperes, and is used for indicating antenna current at a point remote from the antenna. This instrument is used by hundreds of broadcast stations.

4. **TYPE 760 ANTENNA TUNING UNIT**—This is used for coupling several antennas into a single receiver, or for coupling a single antenna into a number of receivers. Containing six RF amplifiers with an associated power supply, each amplifier stage in this unit has low impedance input and output circuits. These may be series connected for use with a single receiver or antenna. This equipment is especially useful where antennas are remotely located from receivers.

Send in your orders now so that you may receive early delivery as soon as military restrictions are lifted.

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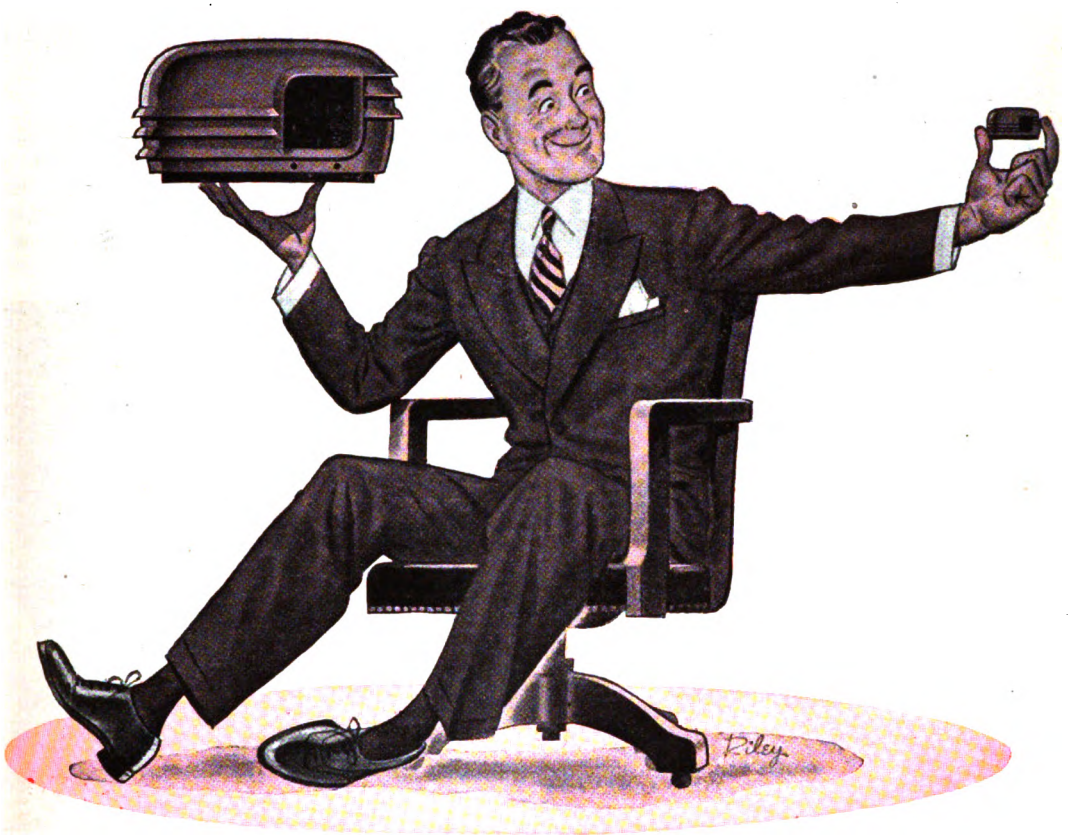
How to make BIG plastic parts seem LITTLE



Radio cabinets, housings, washing machine agitators and such—all the larger and more complicated pieces we used to mold before the war—all will go on the production schedules of smaller, simpler pieces when we get into normal production again. They will have better finishes, more uniform cure, truer color and freedom from internal stress. In other, shorter, words, "Happy Day!"

All we'll have to do is hook up our battery of Heatronic units (*first* in the industry—and still growing) to serve our 500-ton presses.

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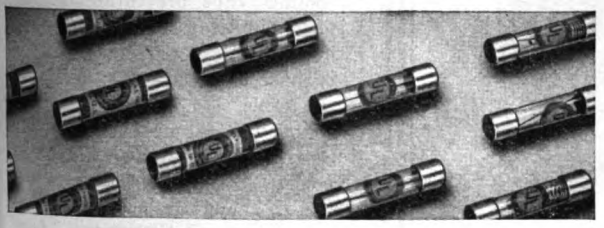
3 AG and 3 AB Fuses



Littelfuse, the first manufacturer to receive Underwriters' Approval on glass-enclosed fuses in current ratings over 3 amps at 250 volts NOW has Underwriters' Approval on fibre-enclosed fuses from 10 amps to 20 amps at 250 volts.

These 3 AB "TINY MIGHTY" fuses (1¼x¼ dia.) will take the place of bulky cartridge or plug fuses and mountings used in heavy-duty electric appliances, power supplies, amplifiers, communications and electronic equipment, radio, motor circuits, etc. To reduce fusing space and weight get approved protection with 3 AG and 3 AB "TINY MIGHTY" Littelfuses.

Ranges of Underwriters' Approved 3 AG Littelfuses, 1/16 amp to 8 amps inclusive; Underwriters' Approved 3 AB "TINY MIGHTY" Littelfuses, 10 amps to 20 amps inclusive at 250 volts or less.

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LITTELFUSE

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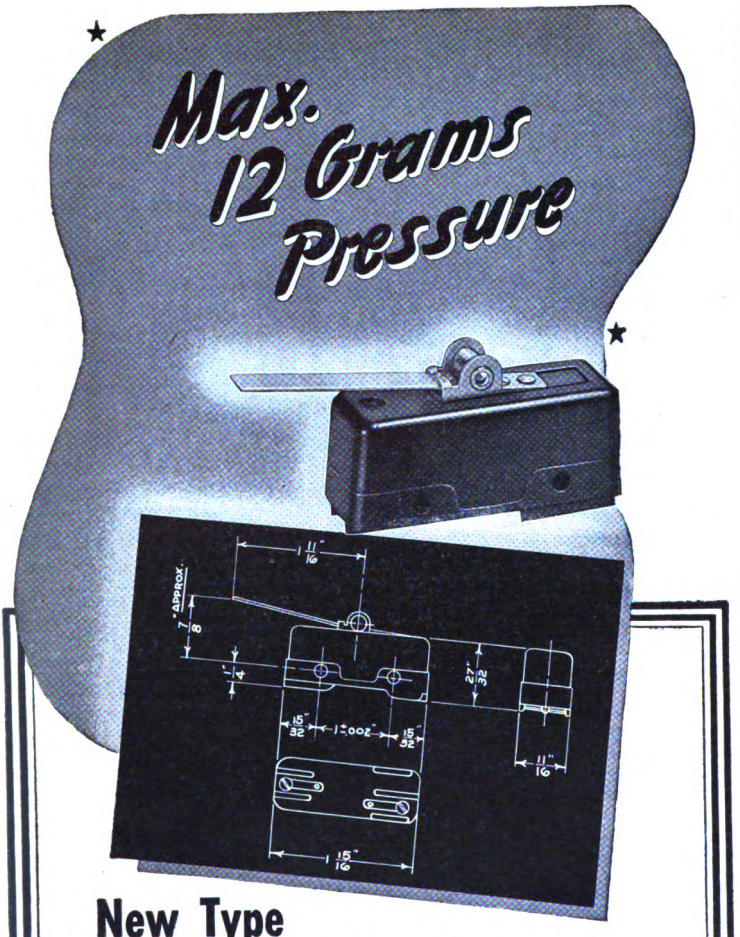

New Type Acro Snap Switch

You can now get Acro precision and long life in a snap-action switch requiring only 12 grams maximum operating pressure. Some special models have been built with operating pressures as low as 6 to 8 grams. Like all Acro switches this new hinged leaf type incorporates the famous *patented beryllium rolling spring*. Pretravel is approx. 3/32"; overtravel, approx. 3/16"; movement differential, approx. .040"; rated 10 amps. at 115 volts A.C. Available for normally open, normally closed and double throw circuits. This is just one of many compact, time-tested Acro designs for better current control. Write for new catalog today.

THE ACRO ELECTRIC COMPANY

1316 Superior Avenue Cleveland 14, Ohio

power contactors. Thus the furnace and instrument heating elements operate together. The two couples in the instrument are equidistant from the heater but the element with the lesser thermal capacity reacts first to changes in heater element temperature.

Operating Cycle

When the two couples in the anticipator are at the same temperature, the voltage from the control thermocouple to the control mechanism is constant. When the control thermocouple causes a change in control current, the change is felt first in the two thermocouples in the anticipator. However, the thermocouple with the lower thermal capacity heats faster than the other and the thermocouple voltage at the temperature control mechanism is increased. This increased voltage causes the controller to change to cooling, thus preventing the furnace temperature from overshooting the desired maximum. When the furnace is in the cooling portion of the cycle, the anticipator thermocouple with larger thermal capacity cools more slowly and its reversed polarity causes the control mechanism to change to heating and keep the furnace temperature from overshooting the minimum limit. A variable resistance in the heater circuit of the anticipator provides a means of controlling the frequency of operation of this supervisory furnace-temperature control.

• • •

Moulding Sponge Rubber With Dielectric Heating

DEVELOPMENT of proper techniques in the moulding of sponge rubber has been studied by a certain midwestern rubber company in consultation with Chrysler Corporation. Among the materials used in the experiments in curing the sponge, were moulds of glass (pyrex), wood, and fibre. Pyrex glass seemed to present the best electrical and structural qualifications. Maple wood was employed for test but found to be undesirable; moisture content varied, and warpage of moulds occurred. Excessive heating of the

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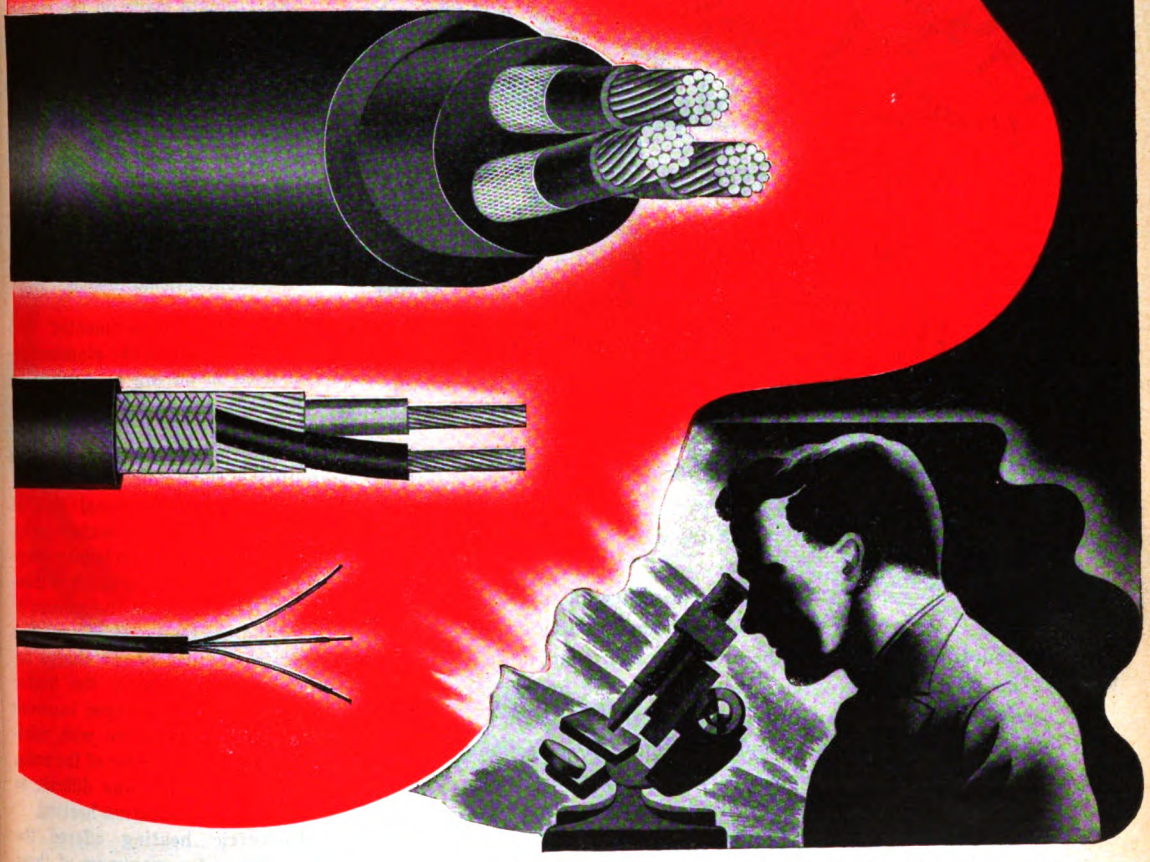

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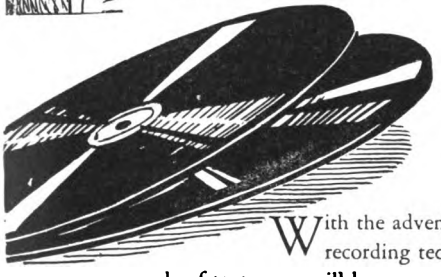

With the advent of new plastics and recording techniques, phonograph records of tomorrow will be pressed in finer-grain, noise-free materials. Recordings, however, can be no better than the pickup arm used in their reproduction. It remained for The Astatic Corporation, therefore, to design a new pickup with advanced characteristics equaling those of the new recordings. This has been accomplished by Astatic through improved featherweight action made possible with the introduction of vertical compliance and new damping materials. The greatest possible fidelity of sound reproduction from these advanced products, so dependent upon each other, will result, therefore, in an ever increasing measure of phonograph enjoyment. Production will begin when essential materials are made available.

"You'll HEAR MORE from Astatic"

ASTATIC Crystal Devices manufactured under Brush Development Co. patents.

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wood resulted. Fibre was tried with poorer results than with wood. Suggestions of using resin impregnated glass cloth developed nothing usable.

Experiments made on the rubber showed that it had a dielectric constant of 2.6, power factor 0.004, and loss factor 0.0008. Attempts to find a material of the same dielectric constant, power factor and loss factor as the material being heated, and that would have no distortion under heat and pressure, were disappointing.

Conventional Moulds

The moulds experimented with were cup moulds of the standard design used in curing by conduction. They were made in the form of a cup with a cover of the same material, and the electrodes placed above and below the mould.

With the conventional type of steam or electrically heated curing moulds, the curing cycle may range from 30 minutes to as much as three hours, depending on the amount of mass and the temperature used. The external surface of the charge being in contact with the heated mould suffered prolonged exposure to curing temperature with minimum cure in the center of the mass. Cellular structure was difficult to control with conduction heating.

Dielectric heating offered the possibility of a maximum of three minutes to attain uniform curing temperature throughout the entire mass. Cellular structure, therefore, would be uniform with a minimum temperature gradient through the mass.

First Method

Sponge rubber was poured into the moulds and r-f power applied at 8 megacycles, 7½ kva maximum output. The electrodes were placed above and below the closed glass container. At the start of the cycle, the container was partly filled, leaving an air gap between the charge and the upper electrode. Heat concentration in the sidewalls of the container developed. Due to the rapid temperature rise possible, a temperature gradient of large magnitude was established between the center and outer sidewall portions

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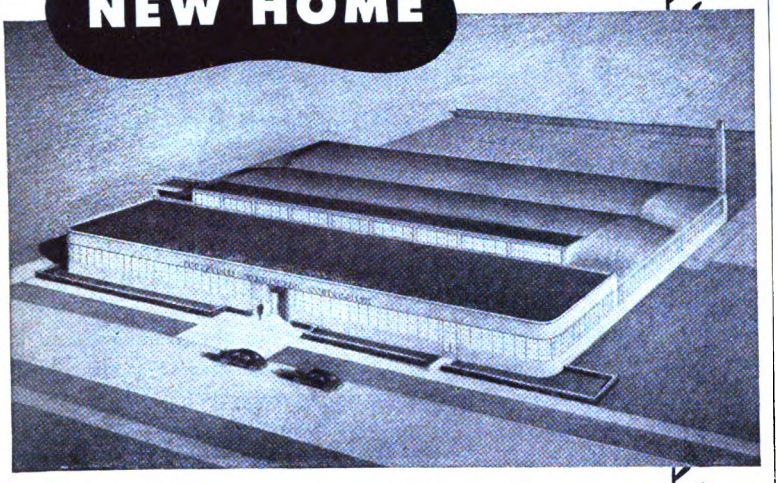
Industrial Condenser Corporation's
NEW HOME



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From this NEW ultra-modern factory come capacitors carefully engineered and accurately produced. Staffed by skilled engineers and backed by 16 years of technical progress, Industrial Condenser Corp. is supplying capacitors for every application. If your specifications call for Electrolytic, Paper, Oil, or Motor capacitors, look to Industrial Condenser Corporation.

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resulting in thermal strains and stresses developing beyond the elastic limits of the pyrex glass.

Revised Mould

Suggestion was made to build the mould from available materials with characteristics not too dissimilar from the charge. The mould qualifications were to be dimensionally stable under varying temperatures and pressures. Electrical characteristics so that too high a temperature as to burn the rubber surface, or too low a temperature so as to retard surface cure, would not be experienced. Pyrex glass was again used and a restraining wall of two by four by four inches internal dimension, open at each end was employed.

An aluminum electrode sheet placed on a slab of insulating material formed the base with the restraining form placed on this. The upper electrode consisted of two units. One was made the same size as the lower electrode and the other slightly smaller than the charge chamber. The second electrode was attached to the larger electrode by small compression springs allowing the charge electrode to enter the charge chamber and rest on the upper surface of the charge mass.

Results

As the temperature increased in the charge, the charge increased in size, which, due to the restraining walls of the form, allowed the mass to increase only in thickness. The work electrode was pushed against its springs toward its parent electrode until it reached its stop gages, placed to control the maximum size of the charge. The container walls were heated by the energy flow from the parent electrode to the base electrode. Due to a much greater distance between the electrodes than between the charge electrode and the base electrode, the container never attained a temperature greater than the charge.

The physical characteristics of the charge were such that as the temperature increased the cell structure became larger, increasing the distance between electrodes at this point. Stabilization was automatically controlled, as no portion

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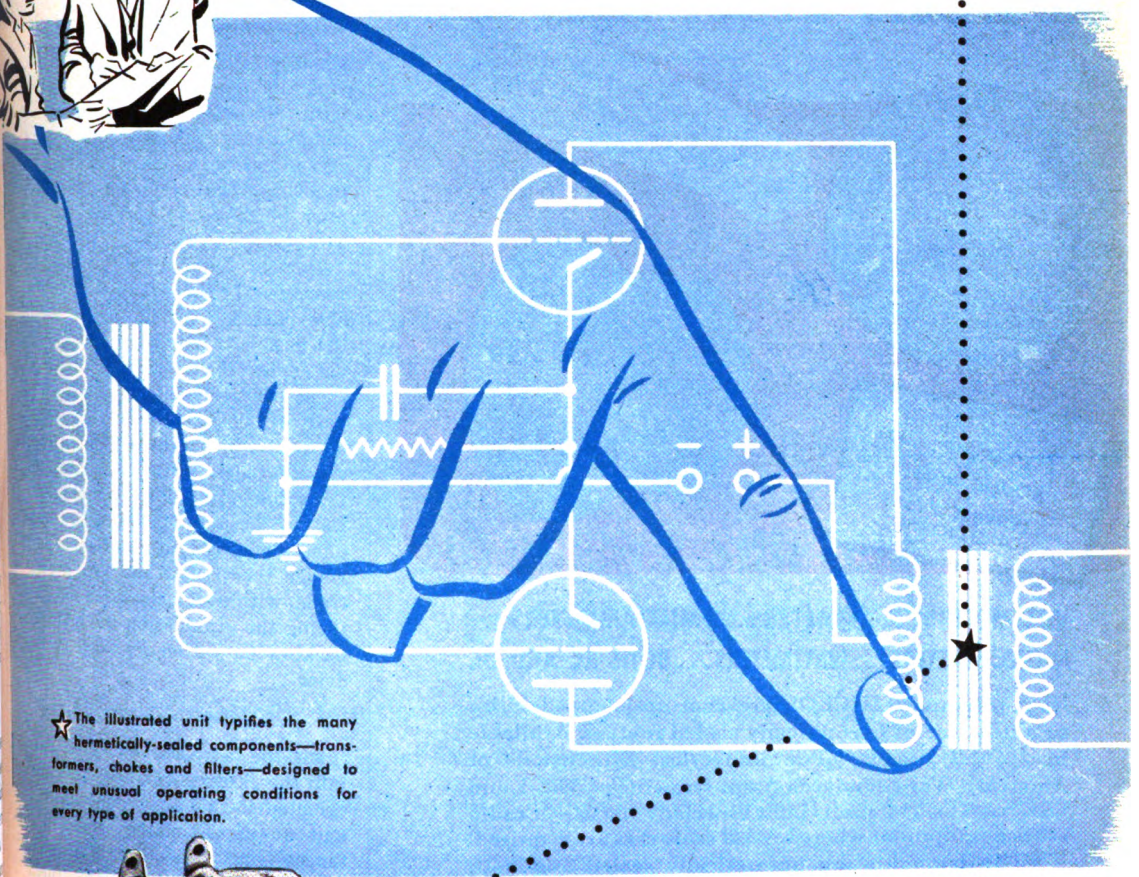

☆ The illustrated unit typifies the many hermetically-sealed components—transformers, chokes and filters—designed to meet unusual operating conditions for every type of application.

—with emphasis on electrical and mechanical suitability!

The N-Y-T Sample Department has demonstrated its ability to continuously supply advanced transformer, choke and filter designs for most electrical and electronic needs. In every instance, all requirements are fulfilled efficiently, and economically.

Let us take care of any samples you may need for new equipment being designed.

Inquiries are invited; address Dept. E

NEW YORK TRANSFORMER CO.

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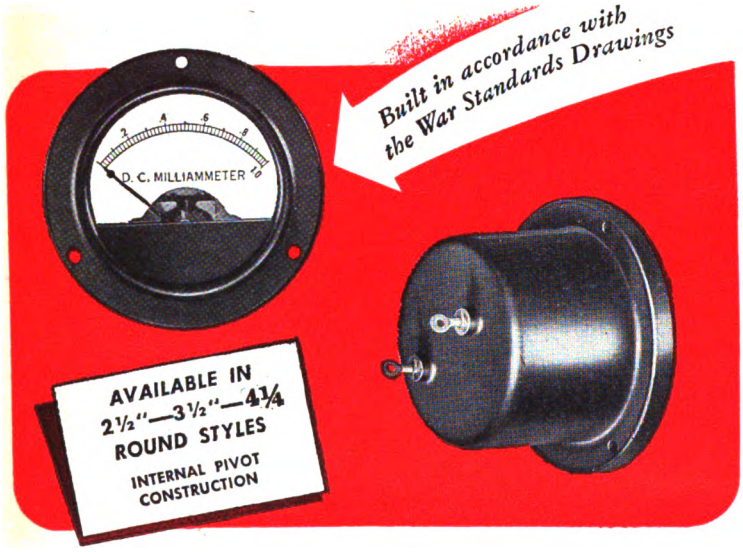
Water Proof, Moisture Proof *and* Steam Proof METERS



VOLTMETERS . . . AMMETERS . . . MILLIAMMETERS . . . MICROAMMETERS . . . WATTMETERS . . . BOTH AC AND DC

Now, you can get HICKOK precision and dependability in a new line of hermetically sealed meters. Available in 2½", 3½" and 4¼" round styles. Dimensions of American War Standards Assn. Drawings C39.2-1 and C39.2-2. The 4¼ size is built especially for use in radio service equipment where several scale arcs are required.

All instruments are hermetically sealed and both vacuum and pressure tested under water. Case fabricated of pressed steel and made corrosion resistant to meet specifications. Terminals are a special glass soldered-in type.

All meters are fully shielded, permitting use on either magnetic or non-magnetic panels. Operation is accurate and dependable even up to 85° centigrade. Internal pivot construction in D.C. types assures longer life and greater resistance to shock and vibration. Write for further information today.

THE HICKOK ELECTRICAL INSTRUMENT CO.
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PRECISION CALIBRATED . . . LASTING ACCURACY

of the charge would heat much more than another. Gradually diminishing temperature rise as the cycle progressed and the electrodes traveled apart was another feature of this fixture that proved very desirable.

• • •

Sandpaper Made by Electrostatic Process

ELECTRONIC RECTIFIERS and an electrostatic process of coating paper with abrasives have produced a sandpaper which is found to increase cutting efficiencies from 20 to 60 percent, resulting in economies of 30 to 40 percent for the average job.

In the electrostatic process responsible for this product, the abrasive particles, sifted to size as in the past, are fed from a hopper to an endless belt. This belt carries them over the negative side of a pair of closely-opposed electrodes between which a high-tension electrostatic field is set up, through the action of a unidirectional potential of around 50,000 volts, supplied by vacuum-tube rectifiers. Under the positive or upper electrode, with its glue-covered surface facing the granules on the belt, the backing passes on its way to the drier.

Effect on Particles

As the abrasive particles pass into the electrostatic field, they are oriented so that they stand on end, and at approximately equal distances from each other. The force of the field then translates them along the lines of force toward the other electrode. Here they are firmly imbedded in the adhesive.

The sandpaper resulting from this process has a coating in which the abrasive grains stand on end, with their sharp points facing outward toward the work. These grains are also securely set at approximately uniform distances from one another.

Electrocoated sandpaper is being marketed with coatings of garnet, silicon carbide, and aluminum oxide, in standard grit numbers from "fine" to "coarse" and with backings of cloth, paper, or combinations.

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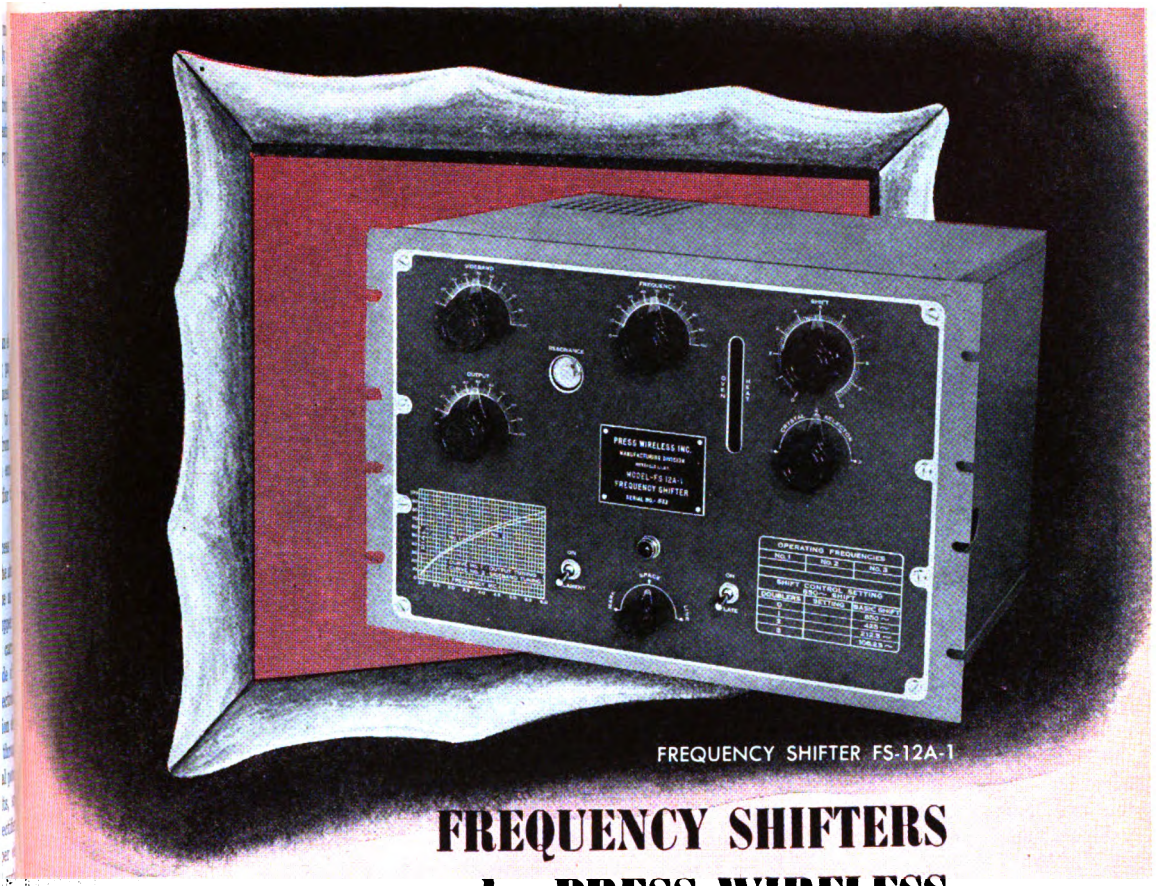

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TUBES AT WORK

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A D-C Amplifier of High-current, Low-impedance Output

By LAWRENCE FLEMING
Naval Ordnance Laboratory
Washington, D. C.

THE PROBLEM of making a d-c amplifier which will deliver a large current to a low-impedance load is difficult to solve by conventional means. Ordinarily the load of a d-c amplifier must be connected directly in the space-current path of the last tube, because a matching transformer cannot be employed. Power tubes require at least 100 volts between plate and cathode in order to conduct sizeable currents; when the drop across the load is but a few volts the efficiency of the system becomes very low. If output currents of more than about 200 milliamperes are needed, an inconvenient number of large tubes in parallel must be used.

Direct-current driving amplifiers are often required for oscillographic work. The amplifier here described delivers up to one ampere to an oscillograph element of three ohms impedance, with a frequency range of zero to several thousand cycles. Since it was clearly impractical to parallel enough power tubes to conduct one ampere (several channels were required), the expedient was employed of using a carrier-current system terminating in an output transformer and a dry-disc rectifier.

Performance

Specifications of general interest are: Maximum output, 1.2 amperes into 3 ohms. Input signal for maximum output, 10 volts d-c. Input impedance, 10 megohms. Frequency range, 0 to 4000 cycles.

The linearity of the input-output relation is shown in Fig. 3. The stability is high and the system operates for months at a time without adjustment.

Figure 1 shows the system in

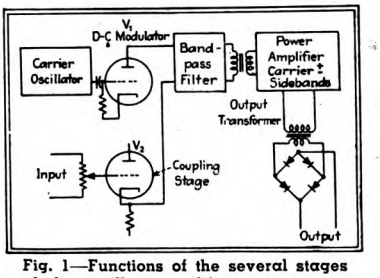

Fig. 1—Functions of the several stages of the oscillator-amplifier arrangement for supplying up to one ampere of direct current to a three-ohm load

block-diagram form. An oscillator supplies carrier excitation to the grid of modulator tube V_1. This tube is operated as a class C amplifier, so that its carrier-frequency output is proportional to its plate voltage. The plate voltage of tube V_1 is supplied by the d-c input signal through a cathode follower V_2. The carrier output of modulator tube V_1 passes through a bandpass filter which passes the carrier frequency and the sidebands, thence through a power amplifier, an output transformer, and a dry-disc rectifier. The d-c output of the system is taken from the rectifier.

Modulator Circuit

The class C type of modulator used has a higher order of stability than the more conventional diode, varistor, or square-law type of balanced modulator. To minimize the residual carrier voltage appearing at the output of the modulator when its plate voltage is zero, the modulator stage may be neutralized, or it may be operated as a frequency multiplier without neutralization. In practice, the latter is simpler and just as effective.

The best tube for use as a modulator is a high-mu triode. The excitation voltage is not critical. Operating constants for the modulator in the system shown are: Grid excitation, 20 volts. Plate voltage operating range, 0 to 10 volts. Load (filter) impedance, 7500 ohms.

Details of Circuit

Figure 2 is a schematic diagram of a complete amplifier channel. The modulator tube V_1 is biased conventionally by means of grid leak R_1 and capacitor C_1. The no-signal plate voltage of V_1 is adjusted by potentiometer P_1, which permits utilizing input signals of either polarity. The cathode follower V_2 is here arranged to drive the cathode of V_1 instead of the plate. A negative signal at

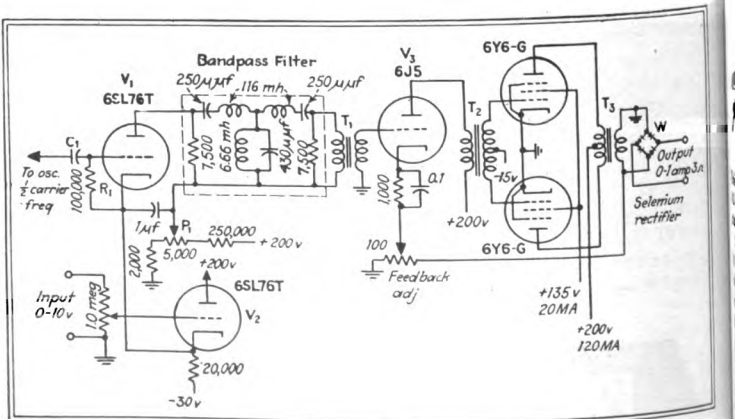

Fig. 2—Complete circuit of the direct-current amplifier. Use of a carrier-current system provides one ampere d-c output without using several tubes in parallel to conduct such a large current

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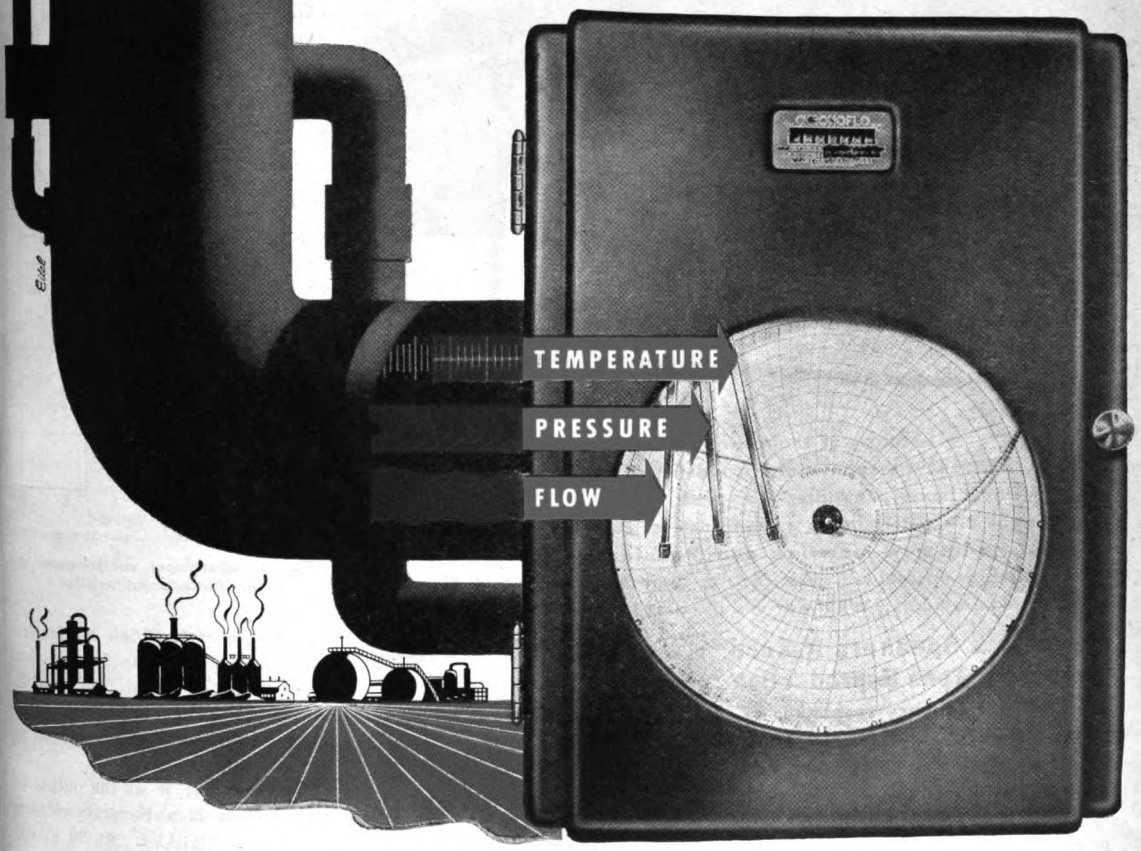
relays FOR REMOTE RECORDING

It is often desirable to tie in the operation of two or more pumps with a single level control, or to coordinate the operation of several pumping stations and reservoirs. In such cases, complete pump, valve, and level control systems may be supervised by the Builders Chronoflo Telemeter, which, by remote control, (using Guardian Relays) *automatically* registers temperature, pressure and flow by a three pen graph writer and on a flow totalizer unit. Chronoflo units are also used for weight control of materials handled on belt conveyors and for other purposes.



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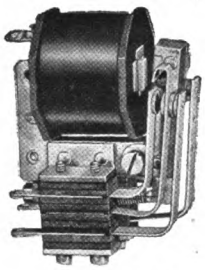

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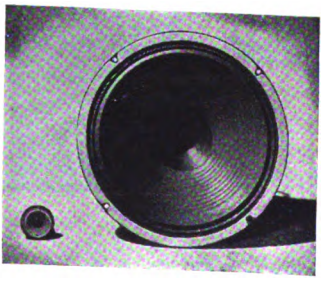

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the grid of V_3 thus increases the voltage between the plate and cathode of V_1.

The bandpass filter should pass the carrier frequency and the upper and lower sidebands. If the percentage bandwidth is small, a tuned circuit can be substituted for the filter.

In this particular case, an overall response of 0 to 4000 cycles was required. The carrier frequency chosen was 30 kilocycles. The filter was designed for a nominal bandwidth of 25 to 35 kilocycles.

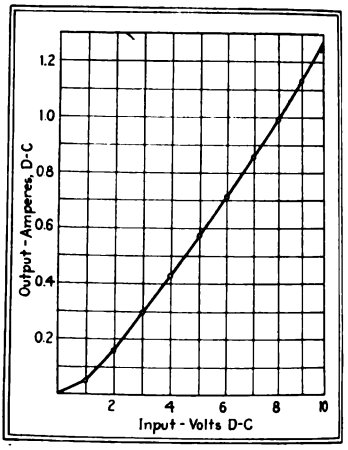

Fig. 3—Input-output characteristics of the direct-current amplifier

Because of the high carrier frequency, special transformers had to be built for use at T_1, T_2, and T_3. At 10 kilocycles and below, ordinary audio transformers should be satisfactory.

The rectifier W at the output of the system is a Federal selenium unit, type 5B1AV1. At 30 kilocycles, the efficiency of dry-disc rectifiers is about half that obtained at lower frequencies. Hence if a lower maximum frequency of overall response is usable, a lower carrier frequency can be employed with a consequent reduction in the size of the power amplifier.

A twelve-channel amplifier of the type described has given satisfactory service for over a year.

• • •

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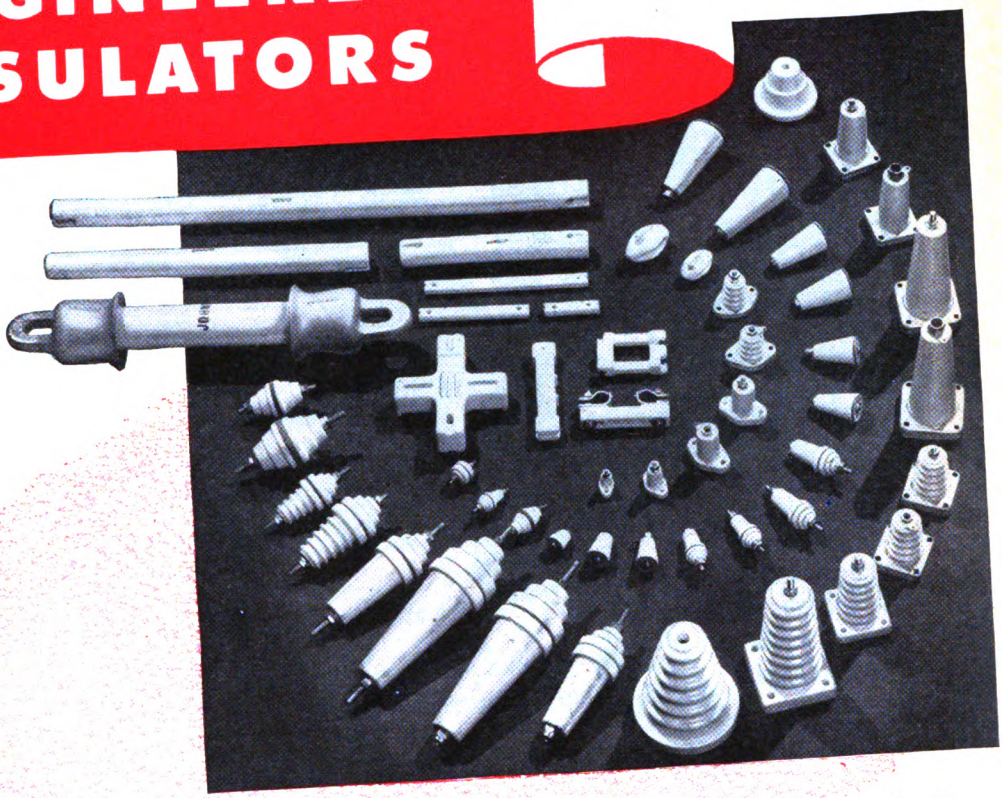

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Electronically switched cardioid reception is used and an output meter indicates in which direction the aircraft should be turned in order to obtain an on-course setting. The tubes which perform the switching are in turn operated by means of a low-frequency oscillator.

Tubes V-1 and V-2 (see Fig. 1) are dual-function triode-hexodes, in which the triode portions are connected to form a push-pull low-frequency oscillator, so that when the grid of V-1 is positive the grid of V-2 is negative. Both hexode portions of the tubes have their input grids connected together and the input from the vertical antenna is fed to this point, the anodes being connected differentially to the loop

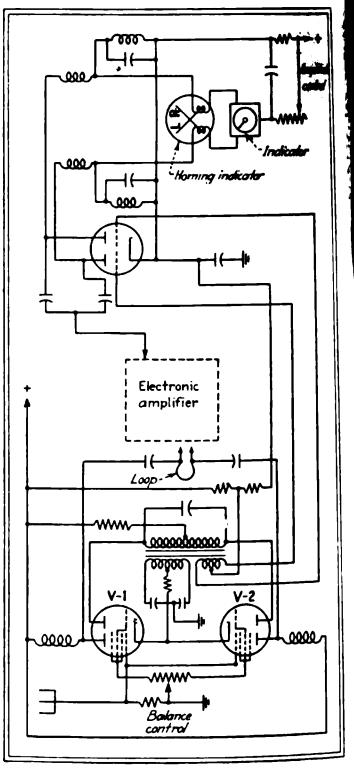

FIG. 1—Functions of the several stages of the Marconator, a British navigational aid for aircraft that combines several d-f instruments into one

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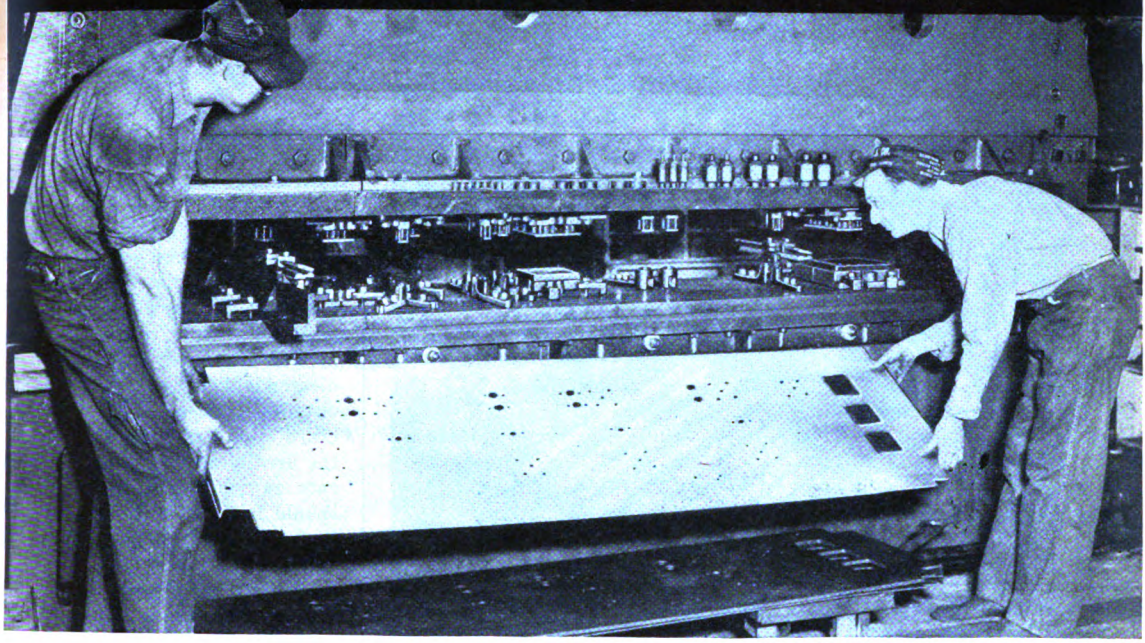

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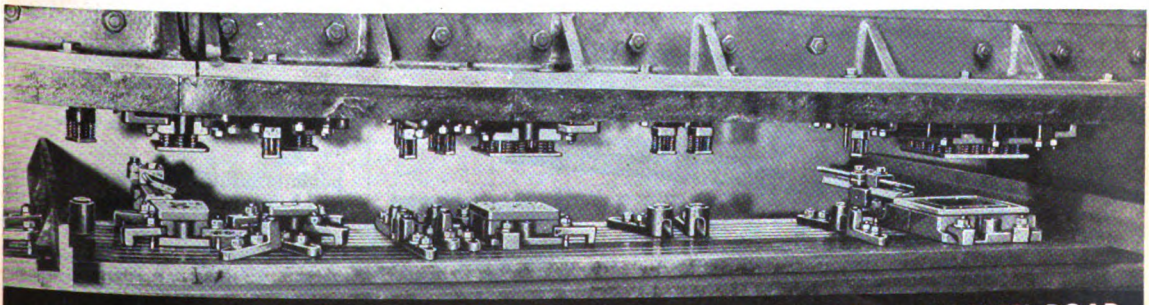

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circuit. If V-1 is amplifying and V-2 is not, the anode current flows in one sense with respect to the loop current and if V-2 is amplifying and V-1 is not, the anode current will be in the opposite sense.

Off-Course Condition

The visual indicator is operated by a double-triode output tube with two anodes acting as diode anodes. Control of this double triode is by the low-frequency switching voltage which alternately operates the h-f tubes. By the above means, the direction of the rectified currents applied alternately to the visual indicator is directly related to the d-f circuits. Consequently, when the craft is in an off-course position, the needle can be arranged to indicate in which direction the loop should be turned. In practice, the instruction is simple, "Turn the cursor toward the needle."

Called the Marconator (Fig. 2), the unit is contained in a metal case about 7 inches square by 4½ inches deep and housing the following components: Single-Needle visual indicator, Amplitude indicator, Master cursor, Relative bearing, (True bearing and drift scales), Gyromagnetic distant reading compass repeater motor, Adjustable quadrantal error compensator, and Loop drive mechanism.

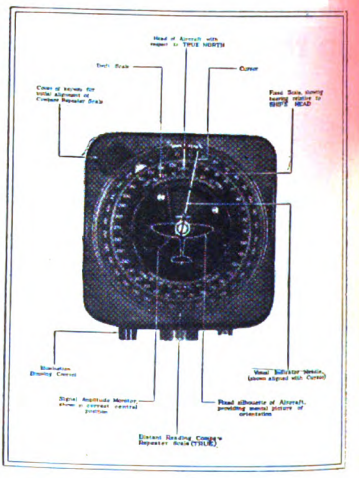

FIG. 2—The several scales of the Marconator are combined into one panel instrument as shown above

Amplitude indication is obtained by an auxiliary movement of the

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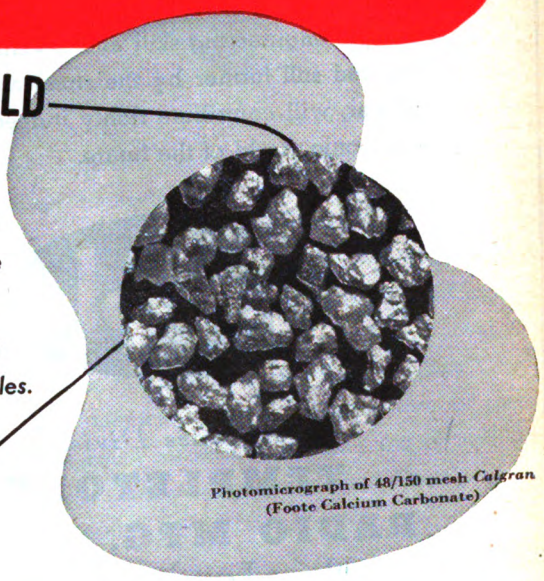

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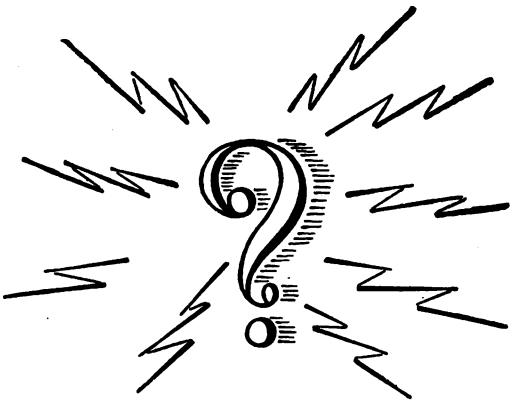

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flag type, to indicate continuance of transmission and to enable the navigator to maintain sufficient output from the receiver to operate the twin-needle type of homing indicator in the pilot's cockpit.

Remote repetition is by a 3-phase, step-by-step mechanism, geared to the compass scale, control being by a master gyro-compass, but indication relative to it can be made during flight by means of a variation-setting control.

Corrections

Compensation of quadrantal error is normally made with a specially shaped cam, covering symmetrical deviations up to a maximum of 15 degrees. In addition, the mechanism permits the correction of errors due to the loop being fitted on either side of the aircraft's center line (field alignment correction) and also errors due to misalignment of the loop. Where the quadrantal error curve does not correspond to a standard shape, special cams are provided. An example of this is in the well-known Catalina flying boats, on which the d-f loop is mounted near the leading edge of the wing and the fuselage is well below the level of the wing. In this instance the wing produces the predominating influence on the loop, so the sign of the errors is reversed and the shape of the curve generally distorted, owing to the non-symmetrical position of the loop.

Gyro Compass

The gyro-magnetic master compass, with which the Marconator is associated, is a development of the Royal Aircraft Establishment, Farnborough, England. It is a design of particular interest in that it overcomes the airspeed factor, which restricts the operation of the ordinary gyro-compass, by substituting a magnetic compass control for the gravitational control which gives the marine type of gyro-compass its pole-seeking properties. Since this newer gyro-compass can be installed well clear of ferrous material, the magnetic deviation errors are smaller and more consistent than those of the usual compass.

By careful compass adjustment,

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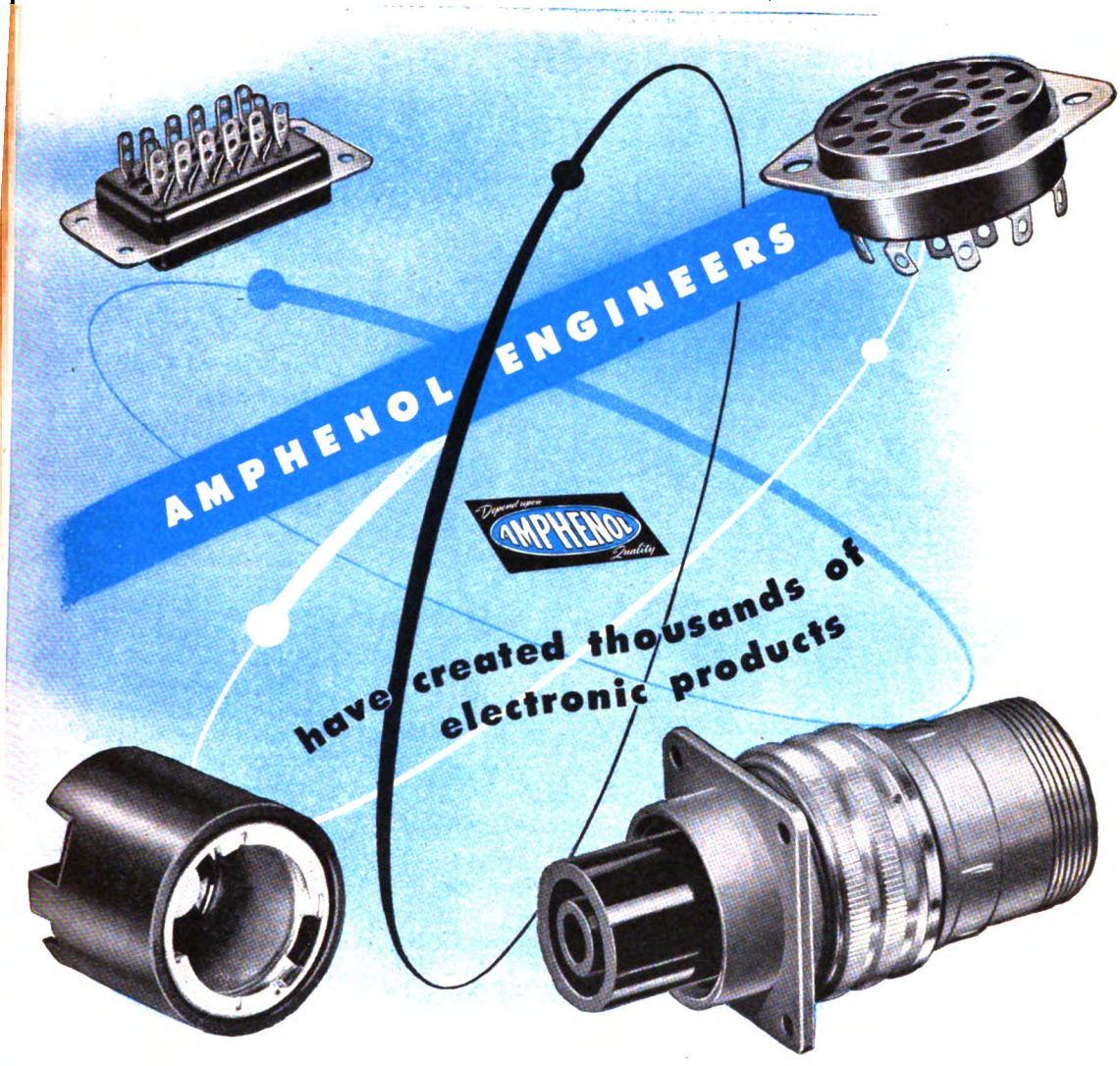

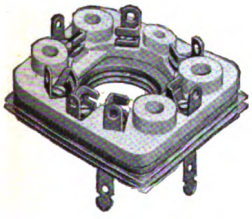

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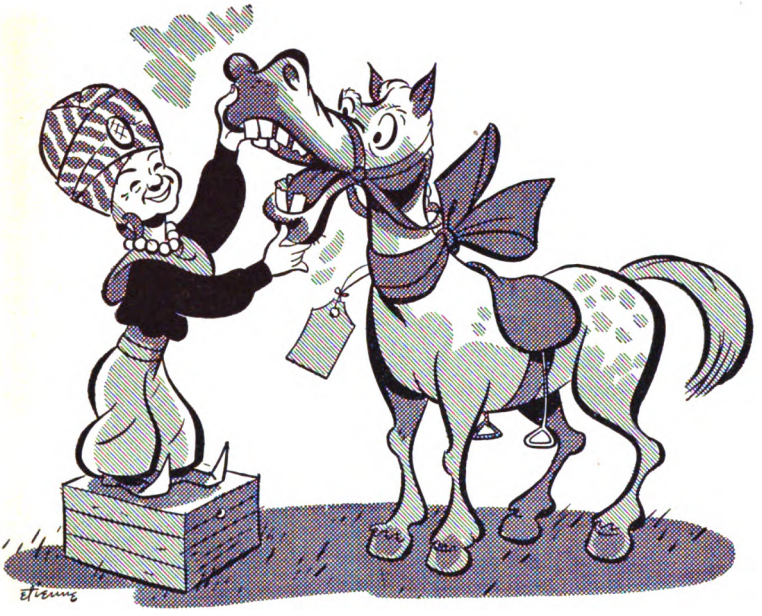

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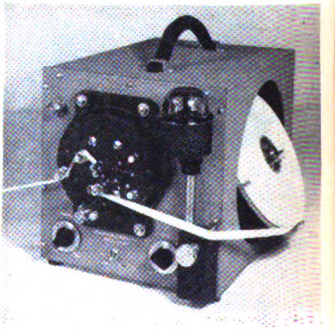
the magnetic deviation errors can be reduced to ±0.5 deg or less. This, together with the mechanical accuracy of the Marconator of 0.5 deg, gives an overall instrumental accuracy of 1 deg or better. In an actual flight test, 96 out of 100 bearings were within 2 degrees and were each taken in a matter of 10 to 20 seconds by one operator.

• • •

High-Speed Code Recording

RECEPTION OF AUTOMATIC transmissions at speeds as high as 1200 words per minute is provided by an inked-tape recorder that connects directly to any communications receiver or can be used on existing land line installations. Announced by Mecanitron Corp. of Boston, Mass., it operates from a standard 500-ohm input impedance.

The circuit of the unit comprises a high-gain pulse amplifier with a special limiter allowing flat output with an input voltage changing from −5 db to +25 db. On-off keying or frequency shift is provided by front-panel control. When frequency-shift transmissions are to be received, a selective tone discriminator circuit assures noise-free transmission and reception.



Mecanitron recorder that inks out automatic transmissions at speeds as high as 1200 words per minute

The standard frequency-shift stations operating on a difference frequency of 850 cycles can be received; any other frequency-shift separation can be obtained by proper tuning of the input circuit. On-off keyed transmissions are received with the bfo set to produce

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Look what plastics plus ingenuity can do

Unsung hero of plastics progress is the custom molder. Through his untiring efforts and remarkable ingenuity, the use of plastics has become extensive in practically all fields of industry. Typical of the thousands of items which have been developed or improved through the intelligent application of plastics, is this Durez phenolic plastic washing machine agitator molded by Eclipse Moulded Products Co.

Reports from users of this molded Durez washing machine agitator attest a definite superiority over those made from other materials. The surface, for example, is permanently clean, smooth and lustrous from the moment it leaves the mold. Furthermore, it is inert to washing solutions and its action on clothes is easy and gentle. Tests which ran as long as 2400 hours continuously proved this agitator to be thoroughly satisfactory in every respect.

Answering A Need

As long as twenty years ago, washing machine manufacturers were searching for a plastic material that could be used in producing an agitator — the only part of the washer that remained the same year after year. The engineers turned to plastics — then in the adolescent stage — because they wanted an agitator that would increase the speed of the washing action while retaining a smooth, glossy surface that would be easy and gentle on clothes.

The Eclipse Moulded Products Company helped pioneer this search, and the molded Durez phenolic plastic agitator illustrated is the evidence of their persistence, ingenuity, and resultant success. Like so many of America's custom molders, they became aware of a need in industry and answered it completely.

Versatile Plastic Used

Needless to say, the plastic used in molding this agitator had to be versatile, and the choice of the proper material was naturally most difficult. A Durez phenolic plastic was selected for two reasons. First, the phenolics, in themselves, are the most versatile of plastics. Second, Durez has specialized in the production of the phenolics for over a quarter century and has a line of more than 300 molding compounds from which to select the plastic that precisely fits the job.

In this case, the emphasis was on moisture resistance, alkali resistance, excellent moldability, and impact strength. In another case, it might well be on dielectric strength, arc-resistance and non-bleeding. In all cases, the versatility of Durez phenolics is the natural starting point when you're struggling for the solution of a plastic material problem. The services of experienced Durez technicians, plus a wealth of proved product development data, are available at all times to you and your custom molder. Durez Plastics & Chemicals, Inc., 328 Walck Road, North Tonawanda, N. Y.

PLASTICS THAT FIT THE JOB

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Is this Memo for you?

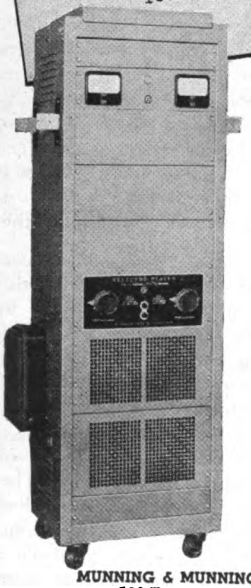
INTER-OFFICE MEMORANDUM

FROM: A.J.R.
TO: Engineering Department
SUBJECT: Rectifiers

Let's stop trying to solve our rectifier problems ourselves. After all, we're not specialists, and it seems to me that it's false economy.

I've just read that Green Electric Co. has over a million amperes of rectifiers now in use in leading companies. That sounds like some sort of record to me, and it also sounds as if Green is the outfit we ought to put on our particular job. Your comments will be appreciated.

A.J.R.



Rectifier Experts...

Yes, Green has a darned good record in the rectifier field. And tough problems are our specialty. We survey your requirements and submit recommendations as to the type of equipment best suited to your needs, from every standpoint. Then, when you give us an okay, we build units to order—or make an adaptation of a standard model. We've got an A-1 rating on both metal-plate (low voltage) and tube (high voltage) jobs—on anything that calls for rectifier equipment.

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RECTIFIER G ENGINEERS

a beat frequency between 500 and 3000 cycles.

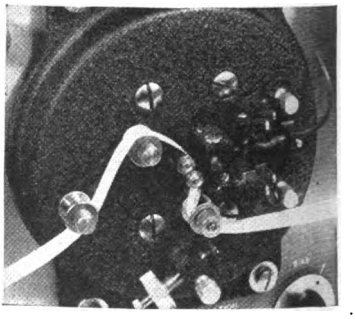
The Mecanitron unit illustrated is standard equipment; another model is available for relay-rack mounting with a tape puller.

Because the unit is constructed with a complete frequency shift receptor, no other equipment is required to secure complete mark and space information for Morse code or teletype use. When the recorder is used in conjunction with a Mecanitron scanner, complete teletype transmitting and receiving terminal equipment is achieved. Use of these two pieces of terminal equipment permits the transfer of printed matter at speeds exceeding 500 words per minute.

Trigger Circuit

For use with standard teletype equipment, the Mecanitron recorder-amplifier comprises a special trigger circuit wherein a pulse is used to drive the moving pen. This allows use of a very low-impedance lightweight moving coil, permitting extreme speed.

The moving coil operates in the field of an Alnico-type permanent



The recording assembly of the high-speed code recorder. A low-impedance moving coil actuates the inking pen

magnet, insuring efficient temperature regulation regardless of climatic conditions. The moving assembly is pretreated to withstand any degree of moisture.

Bias and power controls are provided so that any degree of definition of message can be secured at any and all speeds. Morse code keying, up to 750 words a minute, can be received readily with the power control in the low position. From that rate, speeds up to 1250 words

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It is *permanently* non-fraying, non-stiffening and non-burning, by virtue of the exclusive BH process. It will not dry out, crack or rot, retaining its original unusual resistance to high and low temperatures, moisture, oil, grease and chemicals *indefinitely*.

If you want an all-purpose sleeving that simplifies assembly and maintenance and gives longer maximum protection, standardize on BH *Extra Flexible* Fiberglas Sleeving. Available in all standard colors and sizes from 5/8" to No. 20, inclusive. Write for free samples today and compare by actual test!

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Direct contact with heat up to 1200°F does not harm BH Special Treated Fiberglas Sleeving, the non-burning, unsaturated, flexible-as-string sleeving that stays supple and won't fray when cut. Made in natural color only—all standard sizes. Get this *extra* protection now and keep customers' temper cool, too!

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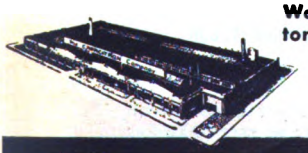

Telephone VAN Buren 3322

The CAPACITRON Company
849 North Kedzie Ave., Chicago 51, Illinois

a minute are obtained with a pen-stroke of ⅛ in. with the power control at full-on position. The character height is adjusted by decreasing or increasing the pen-stroke.

The mechanical assembly allows the thumbscrew removal of the entire pen-arm assembly for quick interchange of parts, if necessary. A constant-flow type of ink-well is used.

One Mecanitron unit has been on test service for four months continuously, 24 hours a day, without interruption. No wear appears on the bearings or on any other moving part.

• • •

Multi-Channel High-Speed Communications With Standard Radio Equipment

By Wayne M. Ross

A MODERN MILITARY communications system is a very centralized affair, all communications originating from and arriving at a central communications office. The high-powered transmitting and receiving stations are usually located at a point remote from this central office. A usual method of interconnection is a multi-channel, d-c/audio tone, converter, combining a number of telegraph signals into a single land telephone line. These signals are then filtered, rectified and used to key the sending transmitter, or incoming, to operate the printing equipment at the central point. In this way an operator, at the central office, can operate, directly, by hand key or automatic sender any particular remote transmitter. Likewise, an incoming signal would be converted to a d-c telegraph signal at the receiver, operate the relay in the audio frequency telegraph unit, sending an audio tone of a particular frequency on to the line, a number of these signals of different audio frequencies being fed to one line. These operate the printer at the central office.

Under war conditions, these land lines, being subject to bombing, are not as dependable as might be desired. In Great Britain in 1942, vhf radio links were suggested and

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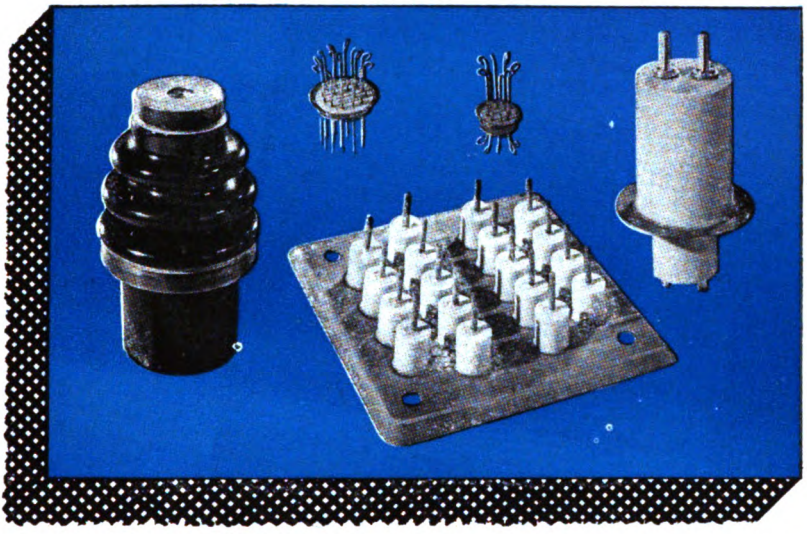
for every climatic and atmospheric condition



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Sealex Bushings are available in single and multiple terminal designs for high and low voltage requirements. Complete specifications and details are available in the Sealex catalogue. Write for your copy today.

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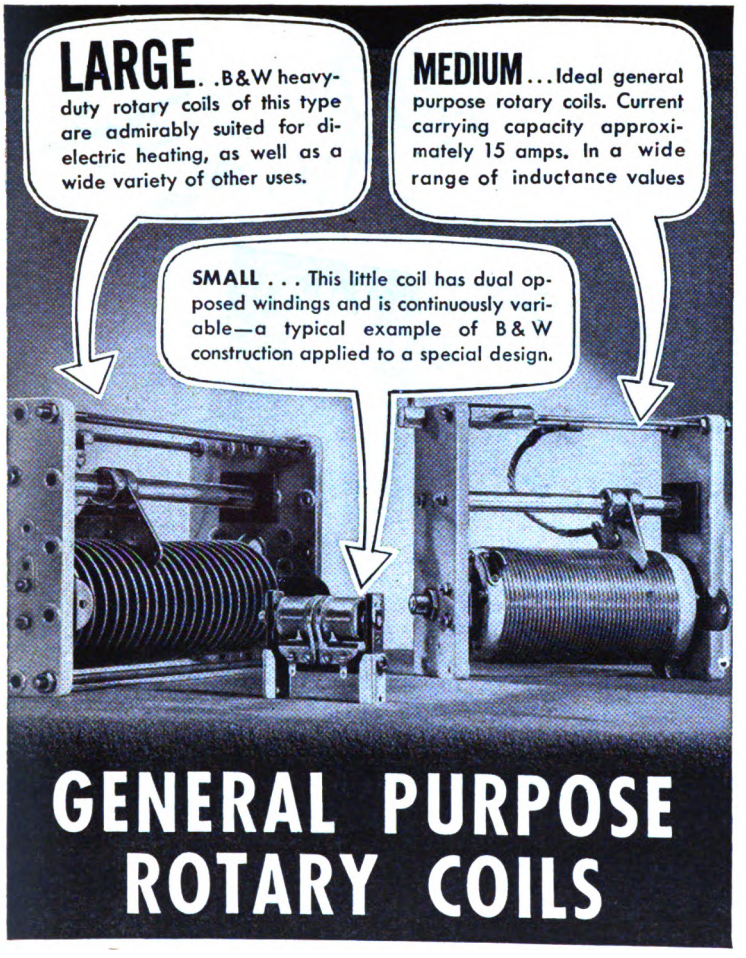

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tried for this service with good results, up to 70 miles, depending on the terrain.

Equipment

The only radio equipment of this kind available was designed for police use and operated in the 75 to 100 mc band. The transmitter was a 100-watt unit having a phono pickup input and was designed for good speech quality.

The receivers were of a conventional type and, like the transmitter, had been designed for high-fidelity speech. They incorporated a diode noise limiter in the detector circuit. They were fixed frequency, crystal controlled, using the 18th harmonic of the crystal frequency for oscillator injection.

In the first attempt to provide this service, the vhf link was set up over a distance of about 70 miles, passing over a range of hills, about 1,000 feet higher than the transmitting and receiving stations, using a four-element array sending and a three-element parasitic array receiving. Vertical and horizontal polarization were tried with the horizontal giving slightly less fading.

The send line from the voice-frequency telegraph was terminated in a 600-ohm resistance and fed into the phono input of the transmitter, the modulation level being adjusted to about 50 percent.

At the receiving end, as the receivers had a 2.5-ohm output for an external speaker, a 2.5-600-ohm transformer with a pad on the line side was used. The output was taken by a short line to the telegraph receiving equipment where the d-c signals were used to operate the conventional high-powered transmitters.

This system worked quite satisfactorily when keying speeds of 40-50 wpm were used, but gave considerable error on higher speeds. This was primarily due to a flutter fading in the receiver carrier. The line level at the receiver required adjustment two or three times per day. Considerable fading occurred about sunset with extremely strong signals after dark and fading again at daybreak.

The next installation was made in the tropics. Here there were two

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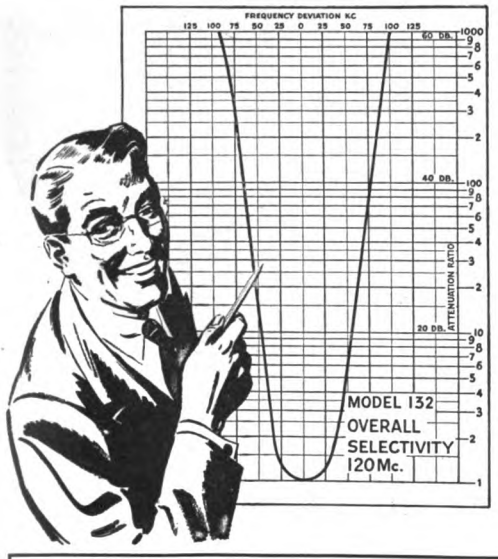
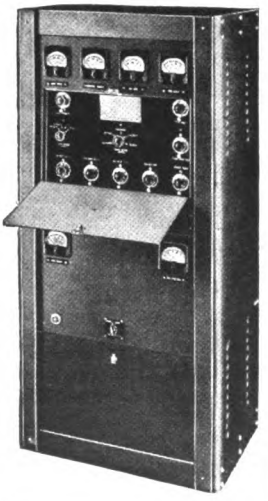


Painstakingly designed and built by seasoned engineers and skilled craftsmen in *limited* volume, COMCO Electronic Equipment, in every way, measures up to highest *custom* standards. Easy to service, COMCO guarantees you long years of dependable performance under all climatic and working conditions.

COMCO TRANSMITTER Model 170

Reliable VHF, 50 watts output. Frequency range 100 to 165 Mc. Cabinet size: Width 23″; depth 18″; height 48″; COMCO Model 127AA Transmitter also available for operation on a frequency range of 200 to 550 kc.



COMCO RECEIVER Model 132

Compact VHF crystal controlled, fixed frequency, superheterodyne. Single channel reception; 5¼-inch relay rack panel mounting. 12 tubes. Frequency range 100 to 165 Mc. Medium and low frequency receivers also available.

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COMMUNICATIONS COMPANY, Inc.

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base establishments, each having high-powered sending and receiving stations. These establishments were separated by approximately 180 miles of jungle and a 4,000-10,000-foot mountain range. The time required for installation, and the difficulty of maintaining a land telephone line, made the vhf system a very desirable project. It was decided to use an 18-channel voice-frequency telegraph system, both sending and receiving, between the two establishments. The 18 send and 18 receive channels were terminated at a small exchange at each end. These channels were to be used for teleprinter service between the two points or control of any transmitting or receiving equipment from the communications office at either end.

Radio Link

The first step was the establishment of the vhf radio link. This was accomplished by setting up transmitters on different frequencies, at each end of the 180-mile link. A mobile repeating unit using a Hallicrafters SX27 receiver, 30-watt portable transmitter and accessory equipment complete with crew set out to explore and test for signal strength all the accessible points near the top of the mountain range.

A site was finally chosen, at an altitude of 4,000 feet in the midst of a tea plantation. The only obstruction to the visual line of sight was a projection of the range a few hundred feet higher than the site chosen and perhaps 20 miles away.

Strength of the signals was extremely good. After a semi-permanent installation using 100-watt transmitters had been made, the carrier was measured and found to be from 50 to 100 microvolts (at the receiver) on all links. This carrier strength was sufficient to operate the receivers with a good avc voltage.

An audio tone was fed over the entire link, originating at one end, then the repeater station linked back, and the signal measured at the originating point. The maximum variation over 24 hours, except for short periods of fluctuation, caused by variation of the portable power units, was 5 db. The wire

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1 2

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● We'd like to reidentify ourselves as the producers of two products not ordinarily associated in manufacture, but often in use. We refer to our molded plastics . . . and our low-torque, *Smooth Power* motors and small electric assemblies.

Our plastic molding ability is well known to many leading manufacturers. Their repeat purchases show their satisfaction at the alertness of our engineers, the ingenuity of our mold makers and the skill of our machine operators. You'll find General Industries' molded plastic parts in homes, offices and industry . . . on your transportation systems . . . yes, they help make the clothes you wear and the foods you eat.

Our *Smooth Power* electric drive mechanisms are built into many phonographs, recorders and combination record-changer-recorders which you play in your home or to whose music you listen on your radios. Their smoothness, quietness and dependability spring from long years of fine designing and accurate building, and fit them for domestic, commercial or industrial products where such characteristics are essential.

At present, our production is 100% military or priority. But, the time is not too far distant, we hope, when we can discuss peacetime business. When that day comes, we'd like to work with you on your needs for *molded plastics* . . . and small *motors*.

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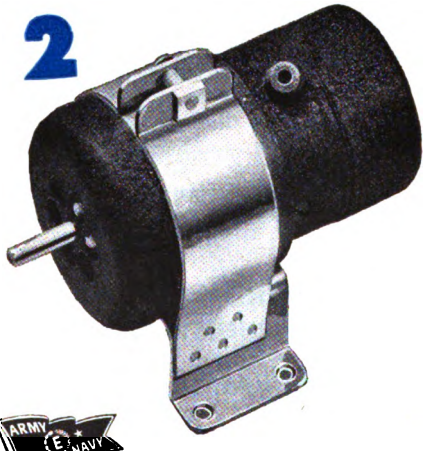

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Our Blue Ribbon Resistors were unique in their entirely new design and their advanced engineering when we introduced them in 1939.

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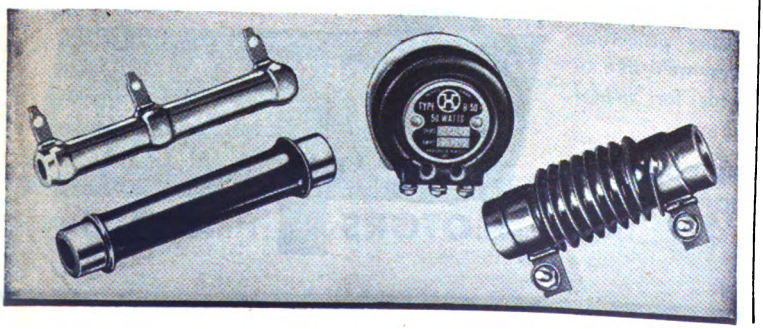

level, except for premonsoon atmospherics, was approximately −50 db.

Cross Modulation

The 18-channel voice-frequency telegraph equipment had an automatic gain control and would accept a variation of ±7 db. It would also operate satisfactorily with a −30 db wire level. The only difficulty encountered was cross modulation between channels. Tests were conducted and the best modulation level for this equipment was found to be about 30 percent. This value was a compromise between wire level distortion and cross-modulation distortion experienced on higher modulation levels. With the additional precautions of careful balancing of interconnecting lines, suitable signal level on these lines (zero db telephone level) and use of carefully balanced modulator tubes, the cross modulation was reduced to a very low value.

This system would operate at signal speeds of 140 wpm on all 18 channels with very few errors. Also available was a standby link which could be used in case of failure of the regular equipment. This link had arrangement for connecting to the telephone exchange of the two headquarters establishments and was used for part-time radio telephone service between them.

• • •

TONE CHANGER

With this machine, a physician can test a hard of hearing patient and determine the tone range that needs help. Called an otometer by Acousticon Research Laboratories, it changes the sound of each word into the limited tones heard by partially deafened ears

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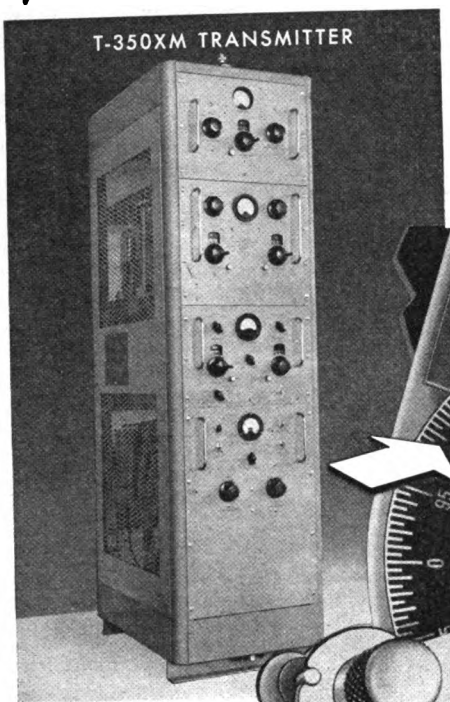
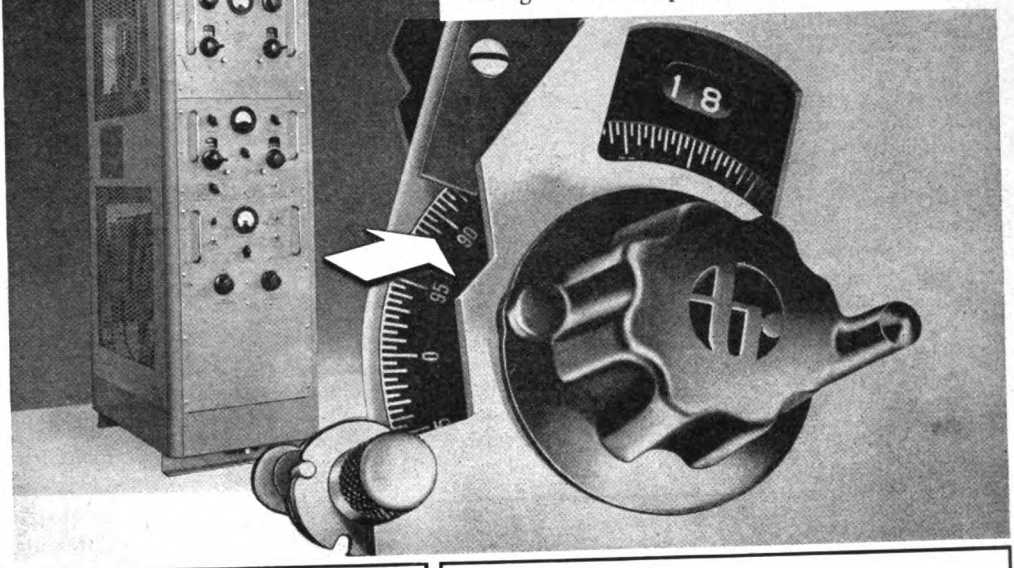
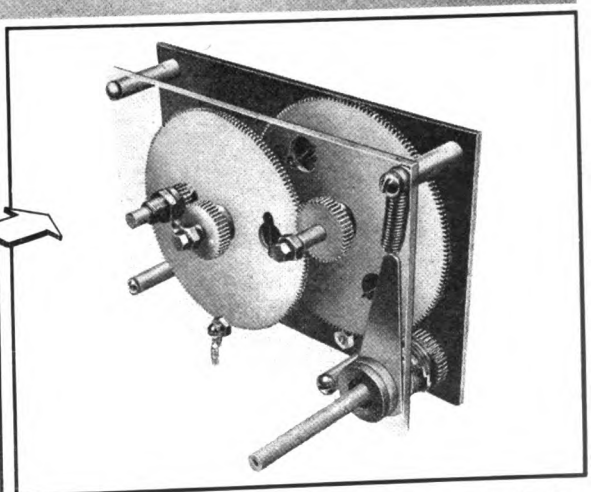
Techrad dials for your post-war panels



The "Counterdial," combining horizontal, drum-type counter with a flat interpolating scale, makes each revolution readable to 200 parts. The substantial phenolic crank-handle knob has molded-in insert to engage slot on dial driving shaft. The non-scrape positive acting dial lock completes this trio.





New additions to the TECHRAD dial group include two gear reduction drives. Ball race bearings, spring loaded for anti-backlash. Dial scale hub rotates 360° for 180° rotation of main driving hub . . . positive stop mechanism . . . 16 to 1 or 27.5 to 1 reductions.

technical radio company

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THE ELECTRON ART

Television Receiver Symposium 252
Anti-Fade Antenna System 272
Electron-microphotography of Atoms 276
Three-phase Power From Single-phase Source 284

Television Receiver Symposium

A PANEL DISCUSSION by television engineers on television receivers that reviewed the status of viewing systems was conducted by the New York section of the IRE at the section's June meeting. The following resume of the technical portion of the meeting combines the material that was presented both during the formal part of the meeting and during the following discussion period into topical groups forming a brief but broad review of the subject as it stands to date.

The speakers were George P. Adair, FCC, who spoke on frequency allocations; I. G. Maloff, RCA Victor Division, RCA, who demonstrated reflective optics; Konstantin Pestrecov, Bausch & Lomb Optical Co., who analyzed refractive optics; Allen B. DuMont, Allen B. DuMont Lab., Inc., who reviewed direct image viewing; Dorman D. Israel, Emerson Radio & Phonograph Corp., who correlated the merits of direct and projection viewing; and P. C. Goldmark, CBS, who discussed color television.

Television Frequencies

There is little possibility of additional television channels being provided below 300 mc. Below 225 mc, channels will be shared with other services. The 480-920 mc

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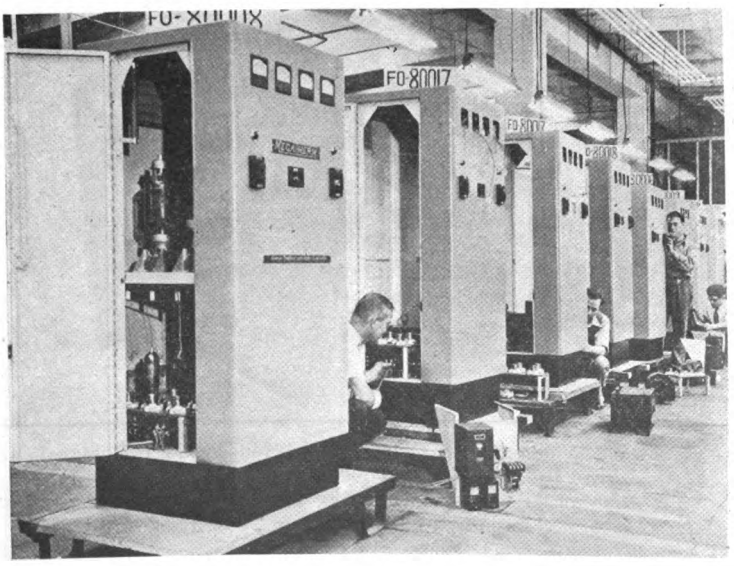
PRODUCTION LINE FOR HIGH-FREQUENCY HEATING



These Megatherm units are built for controlled surface and spot heat treatment in the metal industry and have been used for dielectric heating in the plastics, textile, food and woodworking industries. The assembly-line technique is employed in the plant of the Industrial Electronics Products Division of Federal Tel & Radio Corp.

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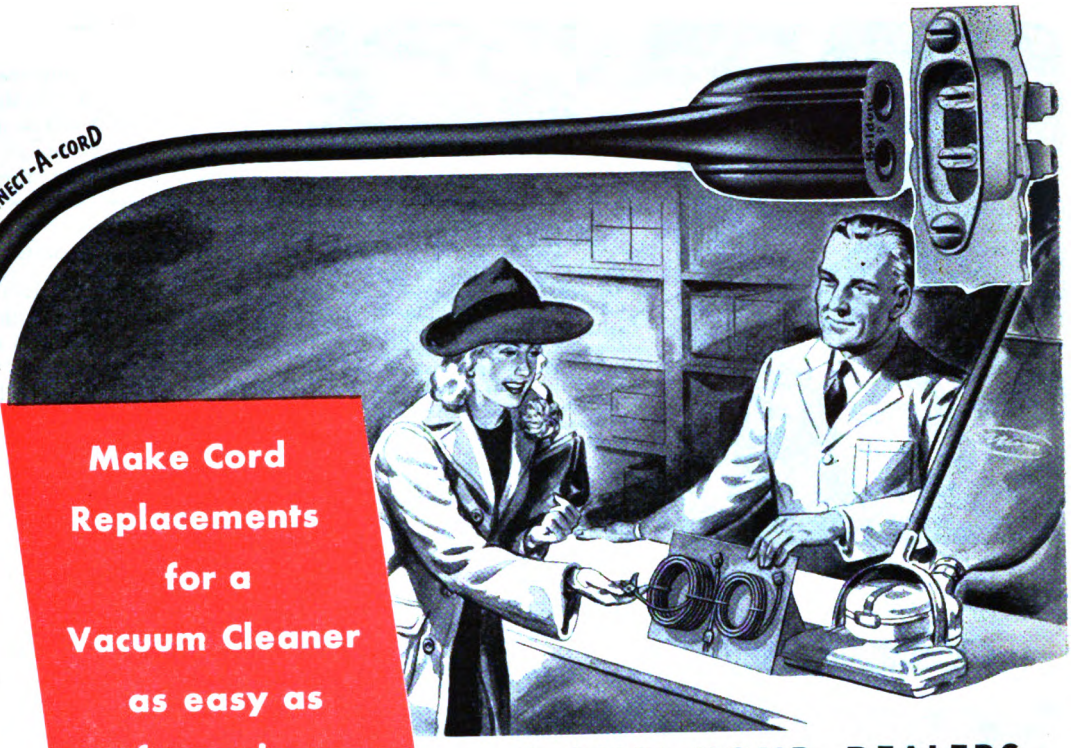
Belden CONNECT-A-CORD



Make Cord Replacements for a Vacuum Cleaner as easy as for an iron

and SAVE YOUR DEALERS COSTLY SERVICE CALLS

with the **Belden CONNECT-A-CORD**

There is something new in electrical cords! Belden Connect-A-corD eliminates costly service calls to repair cords and plugs. Makes replacement as easy and profitable for your dealers as iron cord replacement. The Belden Connect-A-corD

1 Provides a cord for every tool or appliance —detachable at the appliance end as well as the plug end.

2 Is available in various lengths and colors to fit any installation.

3 Simplifies line assembly operation. Simplifies packing and display.

4 Provides a NEW SALES FEATURE.

A worth-while sales feature—promoted by consistent national advertising. Get information on the new Corditis-free Connect-A-corD today.

Belden Manufacturing Company
4625 W. Van Buren Street, Chicago 44, Ill.

what is the Belden CONNECT-A-CORD?

CONNECTOR + CONDUCTOR + PLUG

Users want this new advantage—

It's a new idea—still, as a result of a recent survey, over 33% of vacuum cleaner users were already found to be in favor of the advantages of the Belden Connect-A-corD.

This new Belden product is no "postwar dream." It is already engineered—and only offered after a thorough check which has shown conclusively that your customers want the Belden Connect-A-corD on their better electrical equipment.

Belden *Corditis-free* **CORDS**

Chicago, Ill. Richmond, Ind.

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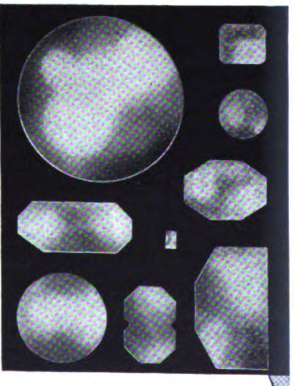
FOR ELECTRONIC, OPTICAL AND SCIENTIFIC APPARATUS



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"BO" POWER RELAY

The "BO" relay is an all-purpose double pole power relay. Like other Allied types it is ruggedly designed yet features compactness and minimum weight. This relay utilizes molded Bakelite insulation throughout. Contact rating is 15 amperes at 24 volts DC or 110 volts AC non-inductive. The "BO" relay can be furnished normally open, normally closed or double throw and is available for either AC or DC service. Weighs 4 ounces.

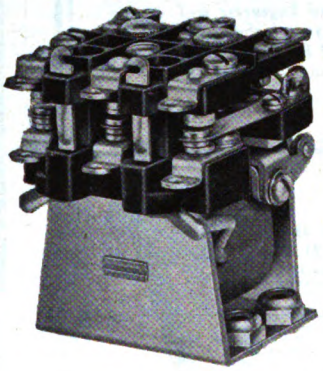
Height 1⅞"; Length 1⅝"
Width 1 13/32"

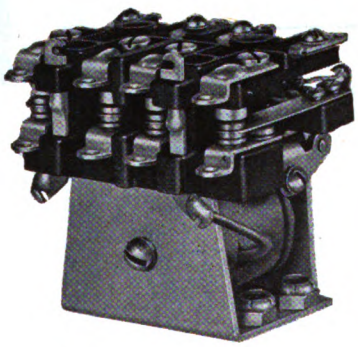
constant progress MARKS ALLIED RELAY DESIGN

"DO" TYPES 3 and 4 POLE

The "DO" three and four pole relay is similar in function to the "BO" type described above. It supersedes the old three and four pole type and features such modifications as simplified terminal arrangements, adjustable contacts, and improved mechanical structure. By using molded Bakelite insulation throughout, greater electrical clearance is provided. Contacts are rated at 15 amperes at 24 volts DC or 110 volts AC non-inductive. Can be furnished normally open, normally closed, double throw and for AC or DC service as specified. Weight for three pole type 7 oz., four pole 7½ oz.

Three pole Height 2¼"; Length 1⅝"; Width 1⅞"; Four pole Height 2¼"; Length 2 1/16" Width 1⅞".





Marking time or "resting on laurels" in no way reflects Allied's engineering and business philosophy. A specific control does a good job . . . but can it be improved? Allied engineers and field staff check its working performance . . seek possibilities to better or broaden its usefulness.

Thus refinements, revisions and modifications in basic types of relays come about—as in the three and four pole "DO" and the all-purpose double pole "BO" types described herein. Keeping pace with the constant engineering progress of manufacturers whose products require electrical control . . . anticipating their requirements . . . epitomizes Allied's philosophy. Let your control problems become our engineering projects.

ALLIED CONTROL COMPANY, INC.

GENERAL OFFICES: 2 East End Ave. (at 79th St.) New York 21, N. Y. *Factories:* New York City (2 East End Ave.)—Plantsville, Conn. Chicago—4321 Knox Avenue, Chicago 41, Illinois. *In California:* Allied Control Co. of California, Inc. 1633 South Hope St., Los Angeles 15, Calif.

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PLUGS and JACKS

...for every known application!

Built in accordance with latest Signal Corps and Navy specifications, Amalgamated Plugs and Jacks are tropicalized to make them fungus resistant, waterproof and moistureproof when called for. Insulators of these components are designed to wthstand extremes of temperatures for −67°F to +167°F, at humidities up to 100%. We also specialize in producing Plugs which will bear up under the high heat met in rubber molding cord sets.

NOTE: Amalgamated Engineers will gladly consult with you on the design and development of Plugs and Jacks for special applications — present or postwar.

PLUG PL-55 and N.A.F. 1136-1

Long sleeve, two-conductor plug, mate to Jack JK-34-A. Withstands minimum of 60 cycles AC. potential of 500 volts effective, applied between any two terminals for not less than two seconds. Meets minimum insulation value of 2000 megohms between conductors at 68°F at humidities up to 100%.

JACK JK-26, N.A.F. 215284-2

Two-conductor Jack, mate to PL-54. Tropicalized. Withstands 60 cycle AC potential of 500 volts effective, applied between any two terminals for not less than two seconds. Meets minimum insulation value of 2000 megohms between conductors at 68°F, at humidities up to 100%.

PLUG, STYLE "A"

Two-conductor, special type plug for use with Neoprene or Buna S molded cords. Same specifications as PL-55.

JACK JK-48

Light duty, two-conductor Jack, mate to Plug PL-291 and Plug 291-A.

PLUG PL-204

Hand set. A special plug wherein both a modified plug, PL-55 and PL-68, are held in place by a phenolic case. Same specifications as PL-55 and PL-68.

PLUG PL-54, PL-540, PL-354, N.A.F. 215285-2

Short sleeve, two-conductor plug, mate to Jack JK-26. Same specifications as PL-55.

PLUG, STYLE "D"

Two-conductor, special type plug for use with Neoprene or Buna S molded cords. Same specifications as PL-55.

AMALGAMATED RADIO TELEVISION CORP.

476 BROADWAY • NEW YORK 13, N. Y.

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more efficient ...in miniature

ACTUAL SIZE

When the wind blew hard, it was not unusual to put two husky men on the wheel of an old "wind-jammer." Yet today one man easily steers a vessel ten times the tonnage, in any weather, with a wheel about quarter the size. Modern engineering has made this possible.

So it is with miniature electronic tubes. They are not only smaller, but they offer many other advantages when used in high-frequency circuits. Moreover the shorter elements of miniatures are more rigid and are less prone to distortion as the result of vibration or shock.

Manufacturers of radio sets and other electronic devices will find the use of miniatures of greatest aid in reducing the size and improving the function of their new equipment. TUNG-SOL engineers will consult with manufacturers in the designing of circuits and in the selection of tubes. Consultations are always held in strictest confidence.

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vibration-tested

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family of instrument rectifiers

It's a *distinguished* family, this Conant clan of instrument rectifiers. They have taken all the mystery out of the rectifier business.

Over ninety per cent of all rectifier requirements are served by 12 types—4 basic assemblies in 3 series. These 3 series are the three members of the Conant family shown above. Special types, however, can be developed as needed, and you'll find Conant ready to cooperate.

Conant rectifiers are available from stock for immediate delivery on priorities of AA5 or higher. MRO, CMP, V3 or MILITARY END USE classifications are recognized.

If you have no priority: File form WPB 547 for your stock requirements. You'll be glad to know this Conant family of rectifiers. They're doing a great wartime job.

CONANT *Instrument Rectifiers*

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4018 Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal.
Export Div., 89 Broad St., N. Y. 4, N. Y.
50 Yarmouth Rd., Toronto, Canada

ture plus the wider viewing angle makes direct viewing preferable for the size images that can be obtained by this method, especially in the home. The limits used in determining the viewing angle were the angles from the normal at which 50 percent of the normal brightness was received.

The lower accelerating voltage of direct-viewing tubes simplifies tube manufacture, and increases tube life over the life of projection tubes by a factor of about two. Spot size is small enough for full resolution by the tube of the transmitted 525 lines (it was stated that this is not possible in the 5-inch projection tubes where great light intensity necessitates a proportionally larger spot).

Direct viewing has the advantage that all the focusing is done electrically, there is no optical alignment and focusing, and there is not the optical loss of light from surface reflection and dust absorption. The direct-viewing system is simpler and thus cheaper, although it has the disadvantage of a curved viewing screen.

Television Receivers

From the customer's viewpoint, the choice between direct and projection viewing will depend on the bulk of the receiver, especially for comparable sized images. The large tube necessary for direct viewing can be mounted so as to be retractable. Possibly the large tube could be incorporated in a bulky piece of furniture but this has the drawback that the complete receiver is no longer a package unit. Projection requires a second piece of furniture—the screen, nevertheless the bulk size is less than with direct viewing and there is the possibility of using the room wall for the screen.

In forcing the brightness of television-tube images, white takes on a hue due to the difference in persistence of the several pigments used to obtain white light from the screen. This constitutes chromatic aberration in the cathode-ray tube, and is most likely to be encountered in tubes for projection systems.

The loss of highlight brightness

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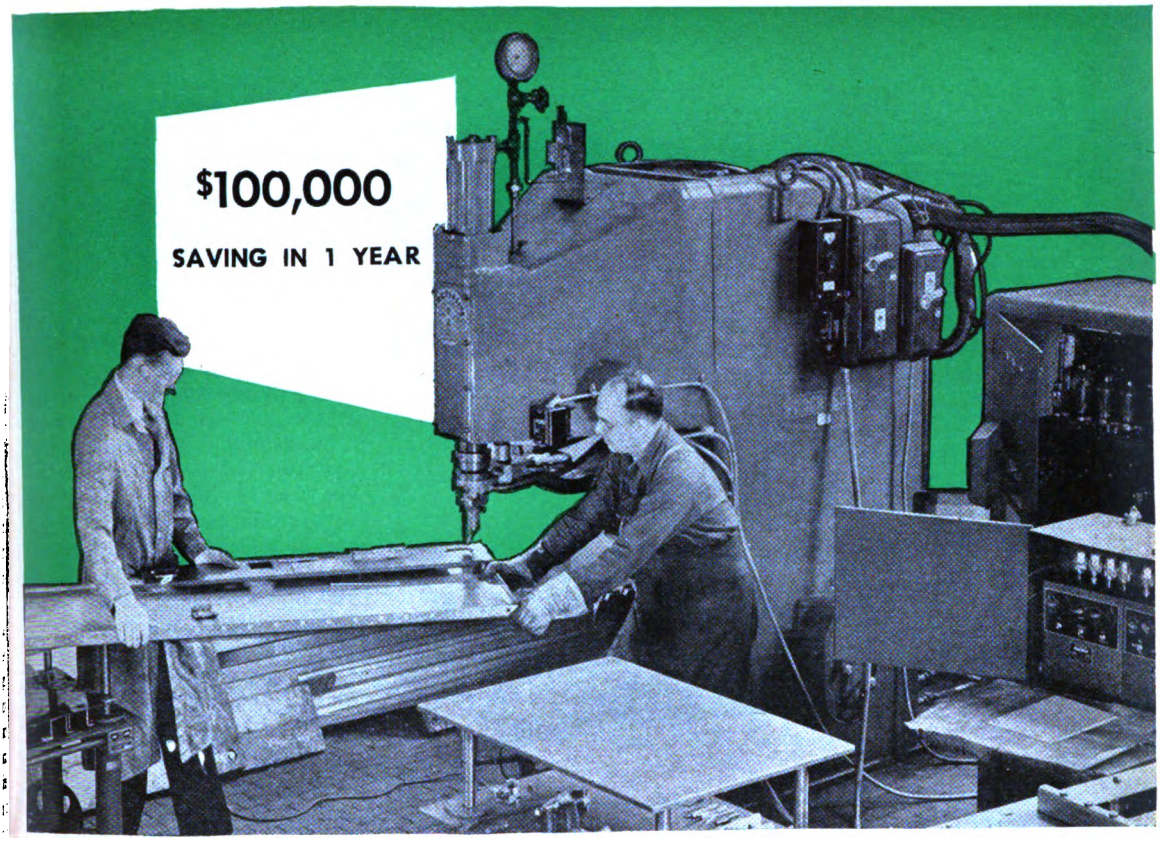

here's what came *out*... when electronics went *in*

A manufacturer of metal cabinets recently installed resistance welding with electronic control—to replace other forms of fabrication.

Here's what came *out* of his fabrication costs in one year: *600 tons of steel, 10,000 man-hours of labor, 3,000 pounds of welding rod.* The total saving amounted to $100,000.

The reasons? Resistance welding with precision electronic control permitted use of lighter gauge stock in the whole structure—with strength and tolerances maintained. This, in turn, permitted better-planned shearing that greatly reduced scrap losses.

Resistance welding control is but one of the many ways electronics is serving industry as a production tool—speeding fabrication, cutting costs, improving products.

For full information on electronic applications for your industry, consult your nearest Westinghouse office. Or write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-91080

ELECTRONIC CONTROL for resistance welding equipment provides accurate control of weld time, heat and timing sequence. Through the precision of electronic tubes, accurately controlled electric current may be sent stabbing through metal as many as 1,800 times per minute.

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Westinghouse *Electronics at Work*

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

ELECTRONIC EQUIPMENT FOR INDUSTRY AND HOME • ELECTRONIC TUBES • RADIO AND TELEVISION

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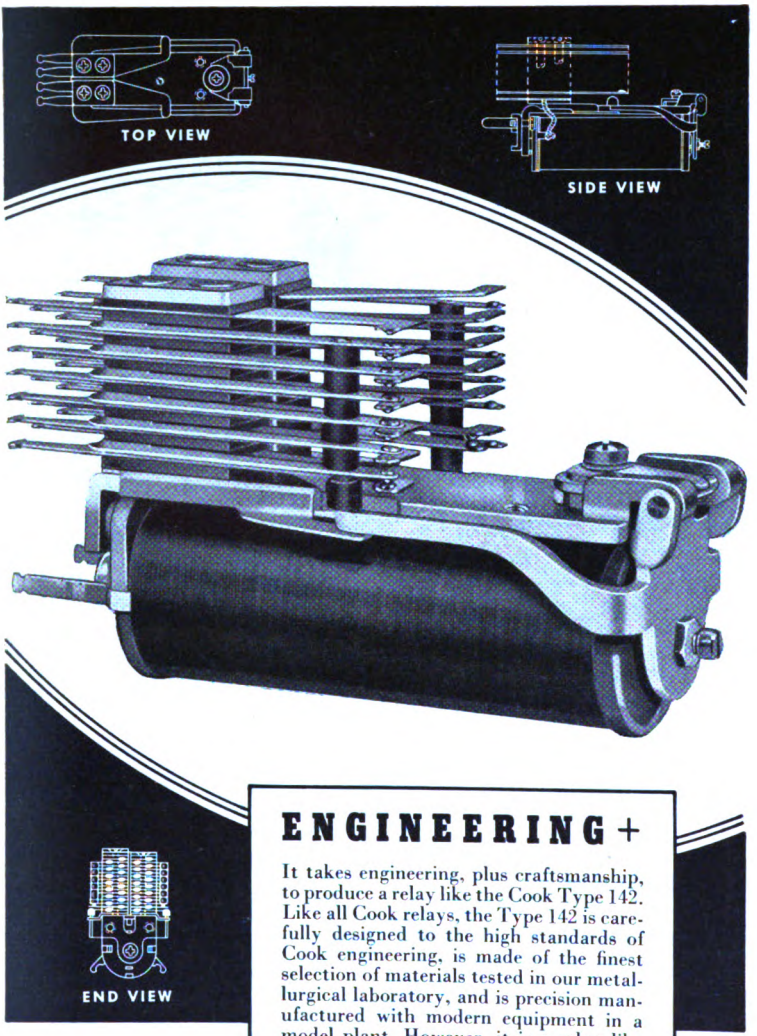

ENGINEERING +

It takes engineering, plus craftsmanship, to produce a relay like the Cook Type 142. Like all Cook relays, the Type 142 is carefully designed to the high standards of Cook engineering, is made of the finest selection of materials tested in our metallurgical laboratory, and is precision manufactured with modern equipment in a model plant. However, it is a relay like this, representing almost the maximum number of spring pile-ups, wherein the qualities of Cook craftsmanship are so predominantly apparent. It is the careful assembly, adjusting of springs, and inspection and testing that produces the unseen qualities of Cook relays.

The Type 142 is a standard type relay operating at 48 Volts, D.C. Armature is of Armco magnetic iron, springs of nickel silver, with bakelite insulators baked at 150 degrees for 100 hours, and phosphor bronze bearing pin. The contacts are palladium and contact combination consists of 11 Forms "A", and one each of Forms "B", "C" and "D".

A Product of the Electro-Magnetics Division of

2700 SOUTHPORT AVENUE
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CHICAGO 14, ILLINOIS

COOK ELECTRIC Company

in projection systems was said to be a definite drawback, giving reduced contrast. The production of a larger image by projection than can be obtained directly was thought undesirable because the lack of contrast gives the impression of poor definition.

Television Reception

Transmission problems at the higher frequencies used for television necessitate placing antennas where the radiation is available. Possible means of increasing coverage and improving reception are the use of repeaters, directional arrays rotating in direction toward the station automatically as that station is tuned in at the receiver, and—for apartment houses—a multiple array receiving antenna feeding a booster amplifier from which r-f energy from all stations is piped along coaxial lines to receivers.

Color Television

The use of absorption color disks appears to be the most satisfactory color system. At present, rotating color disks synchronized at the receiver with corresponding disks at the transmitter are used, but the system can be made completely electronic. Using a 10 mc-bandwidth, 525 line, three-color transmission giving 25 percent better horizontal definition than the present black and white television is feasible. Disks now rotate silently.

The loss of light by color filtering may be compensated by using a black translucent screen. The three-color system gives, if not perfect color rendition, at least a pleasing effect. Use of the black screen constitutes the addition of the black plate used in four color printing. The black screen also makes viewing in an illuminated room possible, the screen being black in the absence of video illumination even if it is illuminated by room light. A direct-viewing, seven-inch, flat-faced tube with a plastic magnifying lens to give an apparent ten-inch image has been used. Either of the two previously described projection systems can be used.

During the question period, inquiry was made concerning the use

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Long experience in designing and manufacturing vibrators has given us the knowledge to build vibrators that are unexcelled for every purpose.

Our engineers, both before and during the war, have had wide experience in developing vibrators to meet rigid specifications. Their knowledge and experience have led them to completely engineer each vibrator —not just make an adaptation from some other type.

The high quality and long life of RADIART VIBRATORS have been demonstrated in millions of installations.

Manufactured by the makers of the famous RADIART Rust Proof Aerials and Radiart Vipower Units.

Write for information on these two products.

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60 DEGREE Horizontal

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The new amazing Altec Lansing multi-cellular Duplex Speaker provides up to 1200% increased area of quality sound distribution in the horizontal plane. Horizontally the Duplex delivers a sixty degree angle of distribution, or twelve times the area distribution at high frequencies as compared to single unit speakers of comparable size. Another reason why the DUPLEX is the SPEAKER that REVOLUTIONIZES the methods of sound REPRODUCTION.

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IN CANADA: NORTHERN ELECTRIC CO.

of light valves. It was stated that work on such systems was being done elsewhere, but that definition and contrast did not compare to that obtainable from cathode-ray tubes. The light source can be as bright as needed. (see Projection Systems for Theater Television, ELECTRONICS, p 218, May 1945.)

• • •

Anti-Fade Antenna System

A DESCRIPTION of an anti-fade antenna system used for reception of a station at Droitwich, England before the war is included in a paper by P. Adorjan, of Rediffusion Ltd., appearing in the *Journal of the British Institution of Radio Engineers* (9 Bedford Square, London, W.C. 1) for Jan-Feb, 1945. Although the paper discusses some of the engineering aspects of audio-frequency wire broadcasting it incorporates the subject of antennas in describing the equipment used at remote receiving stations that demodulate an r-f signal from a central main station (such as Droitwich) and supply local subscribers over an a-f line. Such wire broadcasting has been developed in Great Britain during the past 15 years and by 1943 was subscribed to by about half a million license holders.

For reception of Droitwich, two antennas were placed in a line pointing in the direction of Droitwich, a half-wavelength (750 meters) apart. Halfway between these two, a middle antenna was installed, and the output of the two outer antennas combined through mixer amplifiers.

Phases and amplitudes are so adjusted that the direct ray received on the two outer antennas cancels at the junction point of the two outer antenna mixer units. The output of such a mixer unit will contain, therefore, a signal due to indirect ray only. This output is then mixed with the output of the middle antenna unit. Amplitudes and phases are so adjusted that the final output contains the signal due to direct ray from the middle antenna only.

The use of this system results in a satisfactory signal being obtained

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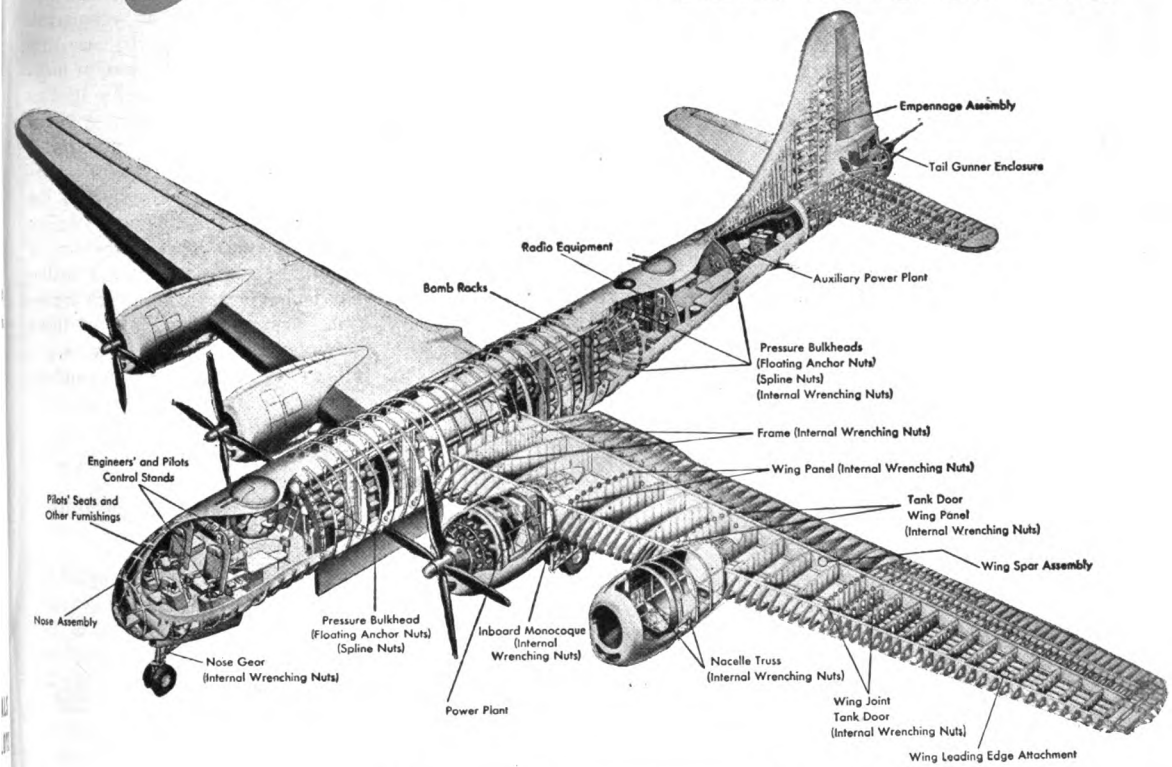
Good connections —AND LOTS OF 'EM!

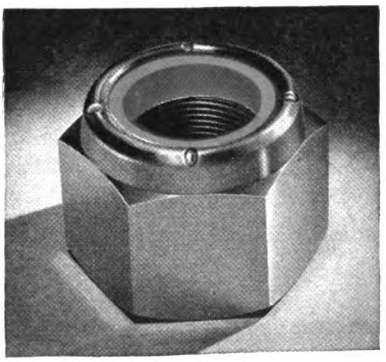


ELASTIC STOP NUTS ON THE B-29

WITH more than 200 separate electric motors, elaborate radio and other communications and detecting equipment, landing lights, other lighting installations and other related equipment, it's no wonder that the giant Superfortress, the great Boeing B-29, is widely known as the "all-electric" plane.

And it is highly significant that many of the 75,000 Elastic Self-Locking Stop Nuts in a single B-29 are used to guarantee tight, trouble-free connections throughout the various electrical and electronic installations.

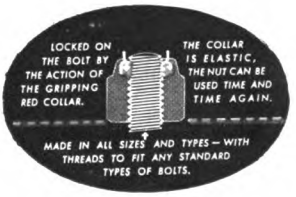
No frying noises, no spotty reception, no broken transmission, no light failures, no door-jamming, no fatal defects in critical detecting apparatus—not from loose nuts, when the famous red-collar nuts are used as they are on the Superfortress.



Better performance from better products can be certified when "red-collar control" is given both products and production machinery, because Elastic Stop Nuts positively will not shake loose! They hold their place. Yet they are easy to remove, and can be used over and over again.

For firm, hold-tight connections in electrical and electronic equipment, specify the nut with the red collar, the Elastic Self-Locking Stop Nut.

LOOK FOR THE RED COLLAR
THE SYMBOL OF SECURITY



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The "Honeycomb" or Universal Lattice Coil is still a popular winding in radio frequency circuits or as R. F. Chokes.

We can furnish this type of winding on tubes, dowels, resistor forms and iron slugs to close inductance tolerances and conductor sizes from #18 to #40.

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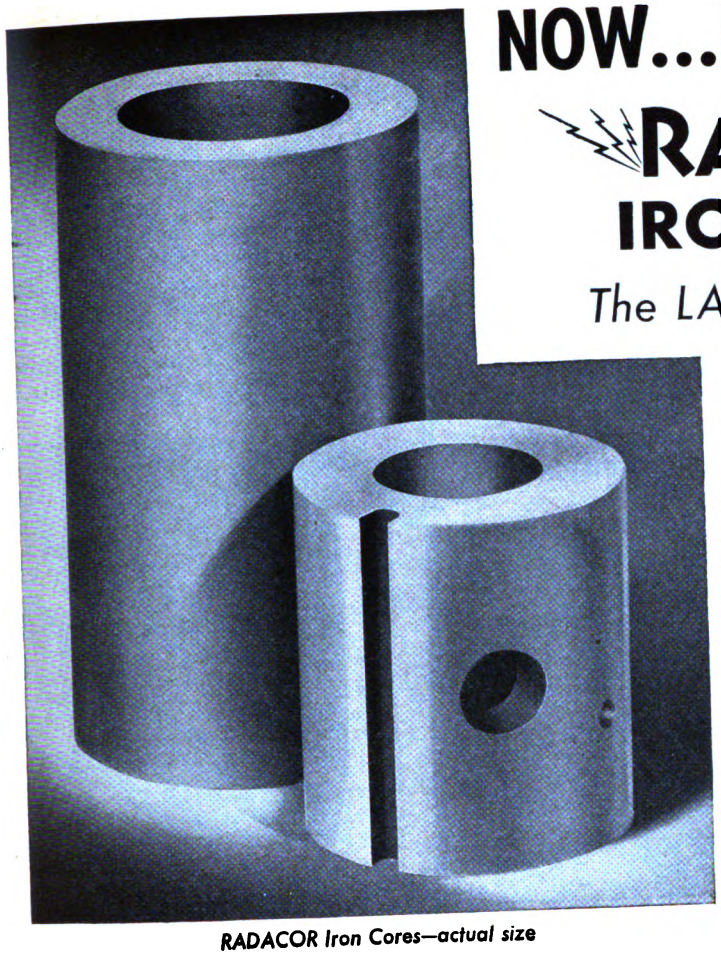
RADACOR IRON CORES

The LARGEST ever built helped the B-29's accomplish their tasks



RADACOR Iron Cores—actual size

RADACOR is the result of exacting wartime demands. When an exceptionally large core with precision milling and extreme electrical and physical tolerances was required for equipment built into B-29's, only RADACOR fulfilled the needs, accomplishing results *never achieved before or since!* GENERAL ELECTRIC COMPANY built the antenna loading units, and orders followed from Stewart-Warner Corporation, Hammarlund Manufacturing Company, Inc., and Sentinel Radio Corporation. We received the largest orders ever placed for one type of Iron Core within a period of a few weeks, totaling almost a half-million dollars.

Such acceptance should merit your consideration when planning the use of Iron Cores as a component of your radio equipment. Our engineering staff of core specialists and our laboratory facilities are available for your specific requirements.

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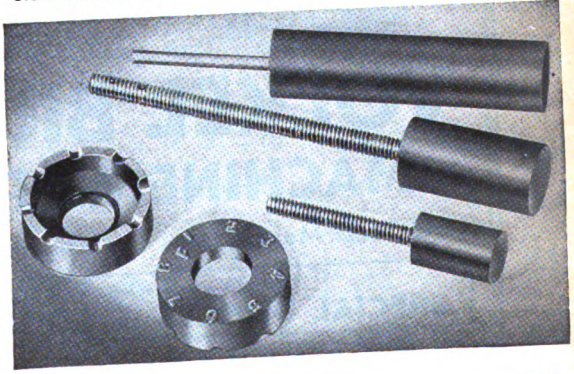
High "Q", high permeability (appr. 30) Iron Cores for use from 400 KC to 2000 KC. Write us your postwar requirements today.

RADACOR Iron Cores are now available in a wide variety of sizes, shapes and ranges, in addition to our complete line of electronic cores.



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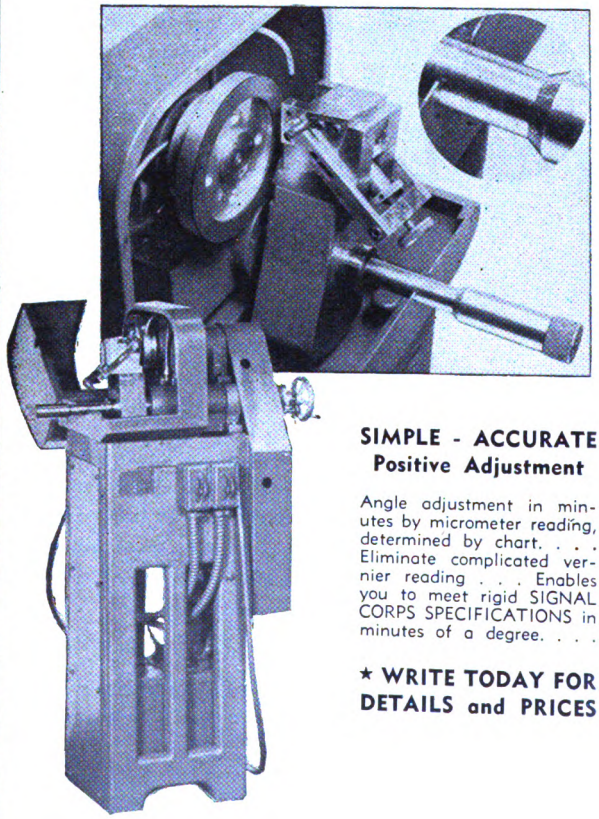

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Angle adjustment in minutes by micrometer reading, determined by chart. . . . Eliminate complicated vernier reading . . . Enables you to meet rigid SIGNAL CORPS SPECIFICATIONS in minutes of a degree. . . .

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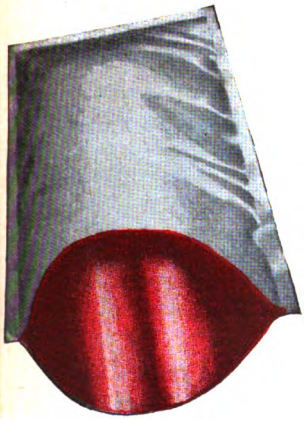

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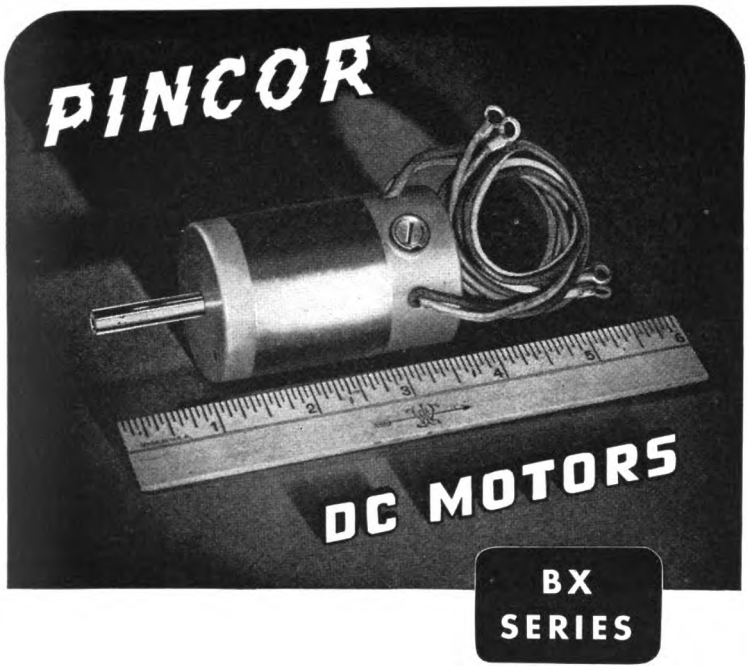

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lines are segmented as is bamboo instead of unbroken as heretofore believed.

The development work carried on at the Physics Department of the University of Michigan has been supported by the Evaporated Metal Films Corporation of Ithaca, New York.

• • •

Three-phase Power From Single-phase Source

By Robert W. Woods

Academic Dean, Union College
Lincoln, Nebraska

Production of three-phase power from a single phase source can be accomplished by using a 120-degree lead-phase shifter, a 120-degree lag-phase shifter, and the original unshifted source connected in the circuit shown in Fig. 1.

Design Curves and Tables

The shifters can be designed so that there is no attenuation of voltage; or in the notation of the

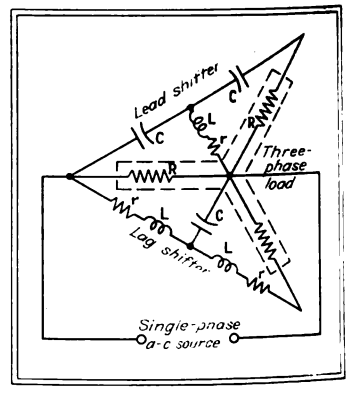

Fig. 1—Connection of lead and lag shifters to obtain power for a three-phase load from a single-phase source

analytic treatment of power phase shifters which appeared in the April 1945 Electronics

$\theta = 120°$
$\tan\theta = -(3)^{1/2}$
$F = 1$

Because in that notation $\omega^2 LC = a$, $\omega CR = b$, and $\omega Cr = c$, it follows that equations for the shifters are

The 120-degree curve for the lead shifter

$$a = \left\{\left[\frac{\sqrt{b^2+1}}{2+b\sqrt{3}}\right]^2\right.$$

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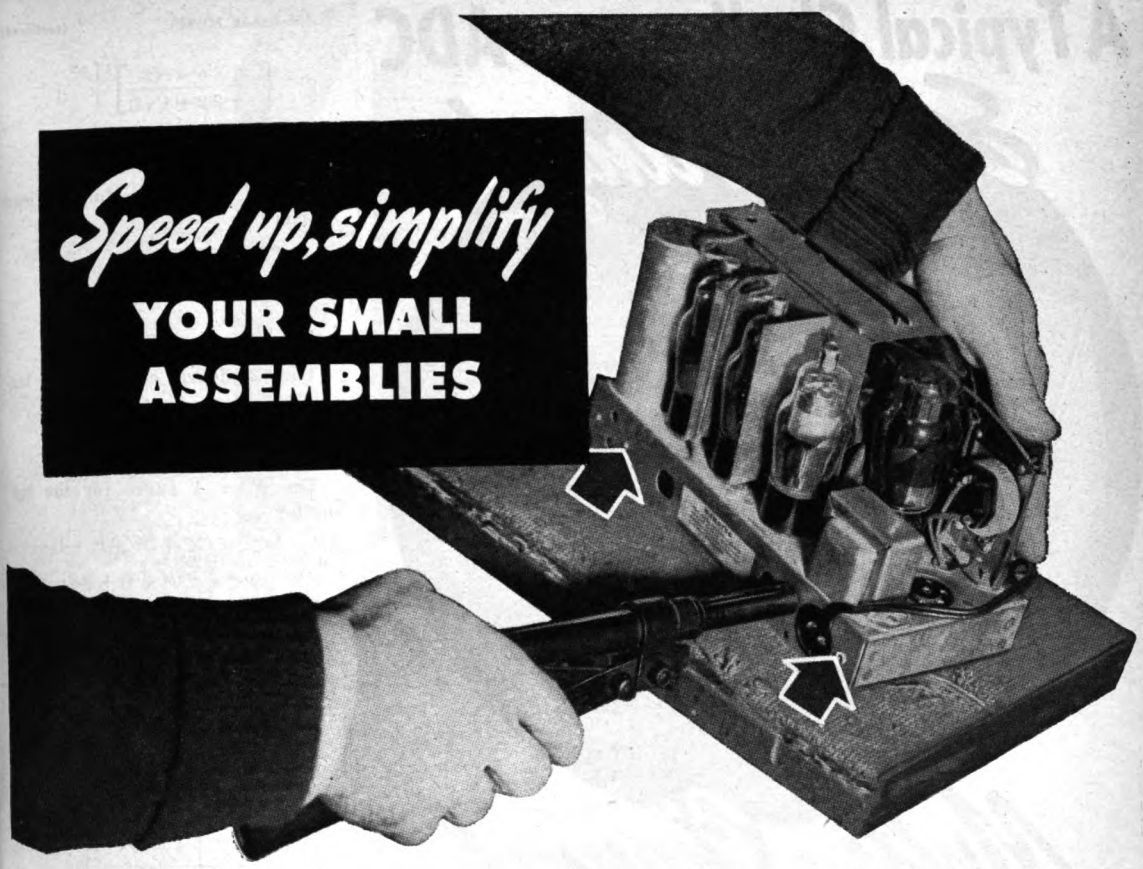
Speed up, simplify YOUR SMALL ASSEMBLIES



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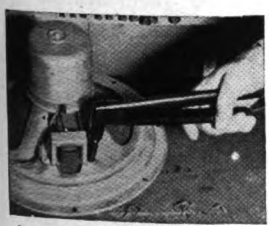
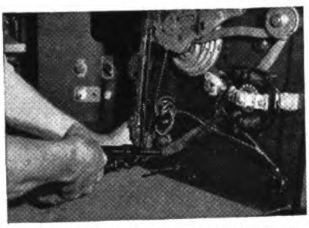
These rivets are upset with a smooth, easy pulling action exerted by small, easy-to-handle Cherry Rivet guns. They can be used on fragile structures, in soft or brittle materials, in all sheet metals, in crowded or cramped locations. Cherry Rivets are installed by one man from one side of any location, blind or not, without bucking. Though they form a strong, tight fastener, they can be easily and quickly removed with trimmers or a drill.

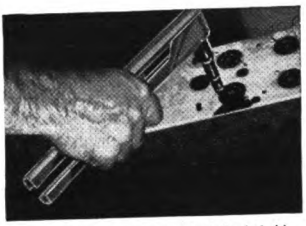
There are several types, sizes and alloys of Cherry Rivets. Installed rivets are strong and neat. The installed cost of Cherry Rivets is low.



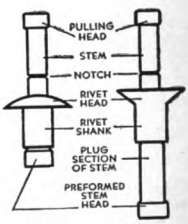
Cherry Riveting transformer to loudspeaker.



Time saved in fastening arm on record changer.



Tube sockets are easily installed; firmly held.



For a quick glance at the many types and uses of Cherry Rivets, write now for illustrated Manual D-45, Department A-120, Cherry Rivet Company, 231 Winston St., Los Angeles 13, California.

CHERRY RIVETS. THEIR MANUFACTURE & APPLICATION ARE COVERED BY U.S. PATENTS ISSUED & PENDING

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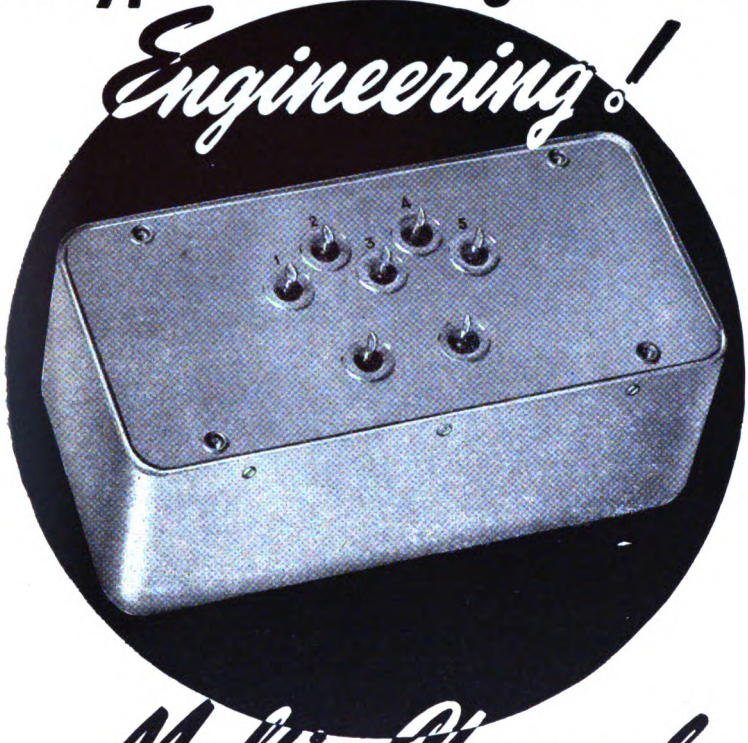
A Typical Challenge to ADC Engineering!



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Electrical performance was improved to provide a midband gain of 14±1½ db when the original specifications permitted a loss from 0 to 6 db. In addition, attenuation characteristics were improved to provide approximately 25 db discrimination at 1/3 octave with bandpass ±1½ db over ±3% of mid-frequency.

These filters are available in single or multi-channel units for frequencies from 200 cps to supersonic and carrier range. Frequencies lower than 200 cps are available with some size increase. Units can also be supplied in combination with high or low pass filters to permit tone channeling on voice circuits, thus allowing several remote control functions to be superimposed on a single voice circuit without interfering in any way with regular service.

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ADC

Audio Development Co.

2833 13th Ave. S., Minneapolis 7, Minn.

THREE-PHASE POWER (continued)

$$\left[c + \frac{b - \sqrt{3}}{2(2 + b\sqrt{3})}\right]^2\Bigg\}^{1/2} + \frac{1 + b\sqrt{3}}{2\,(2 + b\sqrt{3})}$$

The $F = 1$ curve for the lead shifter

$$a = \left\{\left[\frac{b\sqrt{b^2+1}}{4}\right]^2 - \left[c + \frac{1}{4}\right]^2\right\}^{1/2} + \frac{b^2 + 2}{4}$$

The 120-degree curve for the lag shifter

$$a = [2 + (b + 2c)\sqrt{3} \pm \sqrt{(4 + 3b)^2 + 16c\,(b + c)}\,]/2$$

The $F = 1$ curve for the lag shifter

$$a^4 - 4a^3 + a^2\,(2c^2 + 2bc + b^2 + 4) + a\,(4c^3 + 4bc + 2b^2) = -[c^4 + 2bc^3 + c^2\,(b^2 + 4) + 4bc]$$

For each value of b, the first two equations determine a design point for the shifter on an a-c plane. The

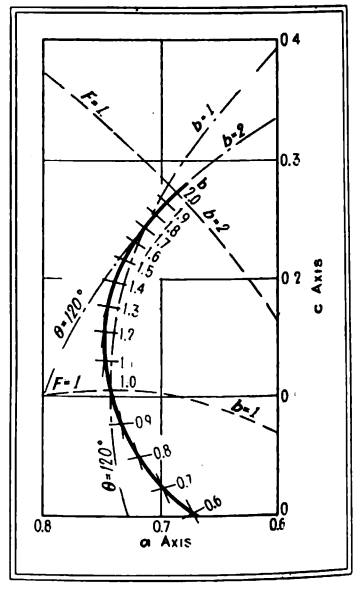

Fig. 2—Design curve for 120-degree lead shifter

locus of these design points gives the design curve of Fig. 2 for the 120-degree, no-attenuation lead shifter. Similarly from the second two equations the design curve of Fig. 3 is obtained.

Because $a/c = \omega L/r$, $c/b = r/R$, and $a/b = \omega L/R$ each design point has associated with it definite values of the above ratios; therefore, if the frequency and load resistance

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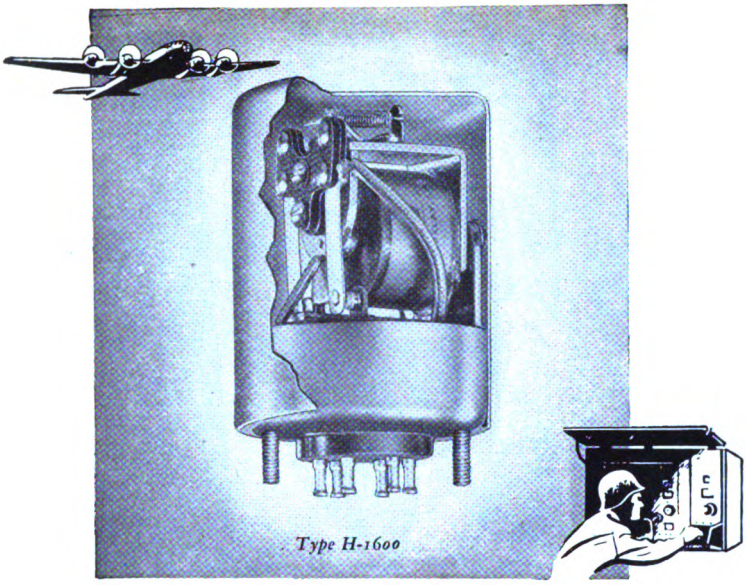

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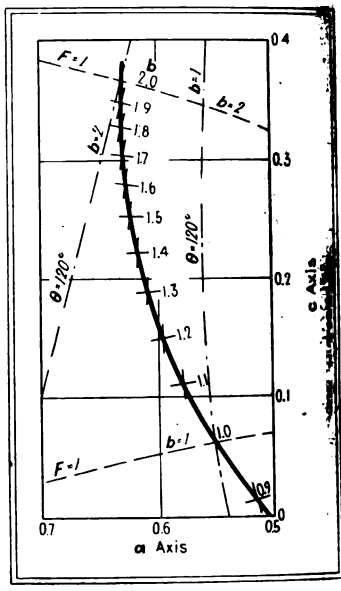

Fig. 3—Design curve for 120-degree lag shifter

R be given, the values of L, C, and r can be computed for any selected design point. The transmission efficiency is also fixed at each design point. It may be shown that, for the lead shifter

$$\text{Eff}_{\text{lead}} = 1/\left[1 + bc\,\frac{[c\,(b^2+2)+ab]^2 + [(2a-1)+bc]^2 + [(2a-1)-bc+b^2\,(a-1)]^2}{[b\,(a-1)-2c]^2}\right]$$

and for the lag shifter

$$\text{Eff}_{\text{lag}} = 1/\left\{1 + \frac{c}{b}\left[1 + b^2 \times \frac{[(b+2c)\,(a-1)^2 + a\,(2-a)\,(b+c) + c\,(b+c)]^2 + [[(b+2c)\,(1-a)]^2 + [a\,(2-a) - (b+c)^2\,(1-a)]]^2}{[a\,(2-a)+c\,(b+c)^2]]^2}\right]^2\right\}$$

To show the corresponding values of these various quantities. Table I and Table II have been prepared.

As an application of these tables, let us design a set of shifters for

Table I—Parameters and efficiency of the lead shifter

b	a	c	a/b	a/c	c/b	Eff.
0.6	0.674	0.002	1.122	270.50	0.0042	0.998
0.7	0.702	0.023	1.103	30.50	0.0329	0.989
0.8	0.722	0.049	0.903	14.78	0.0613	0.939
0.9	0.736	0.077	0.819	9.56	0.0856	0.890
1.0	0.745	0.105	0.745	7.10	0.1050	0.838
1.1	0.750	0.130	0.682	5.77	0.1181	0.795
1.2	0.751	0.155	0.626	4.84	0.1291	0.760
1.3	0.748	0.175	0.575	4.27	0.1347	0.620
1.4	0.742	0.197	0.530	3.77	0.1406	0.552
1.5	0.735	0.215	0.490	3.42	0.1434	0.488
1.6	0.725	0.230	0.453	3.15	0.1438	0.433
1.7	0.717	0.242	0.421	2.96	0.1422	0.386
1.8	0.708	0.254	0.394	2.79	0.1410	0.340
1.9	0.700	0.263	0.368	2.66	0.1383	0.301
2.0	0.690	0.272	0.345	2.54	0.1365	0.268

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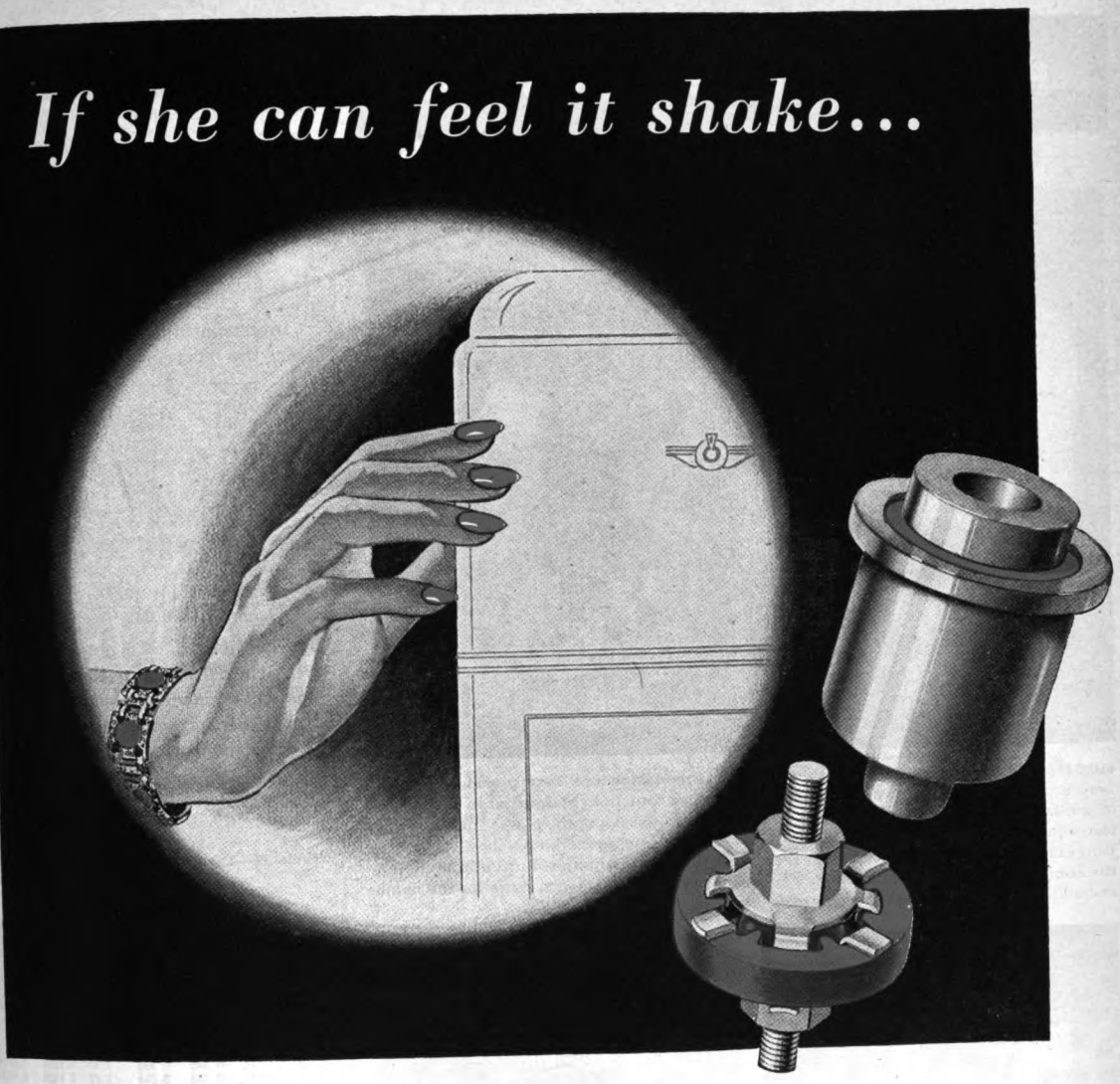
If she can feel it shake...



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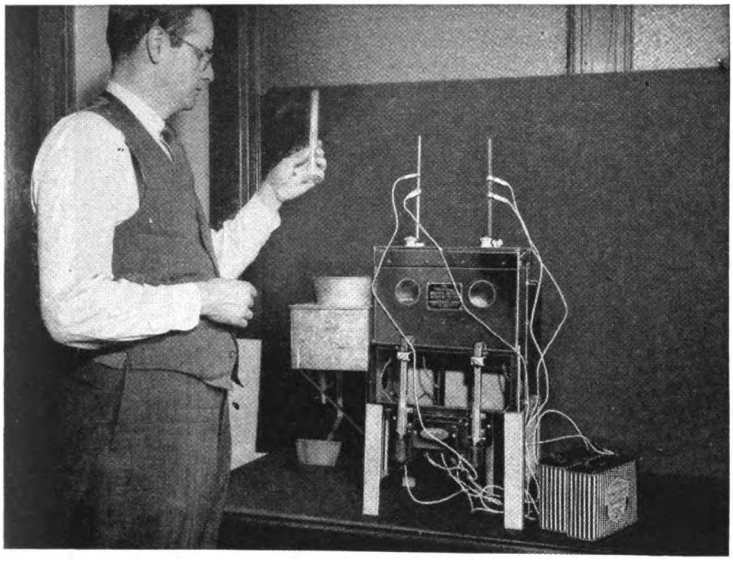
PORTABLE POWER PROBLEMS

THIS MONTH—BROWN-DUVEL MOISTURE METER



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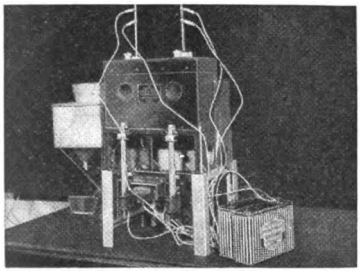

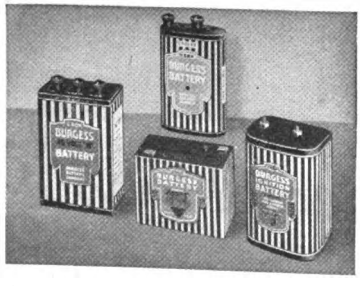

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$$\frac{a}{b} = \frac{\omega L}{R} = \frac{377 \times 0.4}{200} = 0.754$$

Interpolating in Table I we obtain the corresponding values

$a = 0.744$
$b = 0.987$
$c = 0.101$

whence

$$C = \frac{b}{\omega R} = \frac{0.987}{377 \times 200} = 13.1\mu f$$

and

$$r = \frac{cR}{b} = \frac{0.101 \times 200}{0.987} = 20.5\Omega$$

The addition of 0.5 ohms in series with the 20 ohms of the coil satisfies this calculated value of r.

The second and third coils are to be used for the lag shifter.

$$\frac{a}{b} = \frac{\omega L}{R} \frac{377 \times 0.295}{200} = 0.5465$$

Table II—Parameters and efficiency of the lag shifter

b	a	c	a/b	a/c	c/b	Eff.
0.9	0.518	0.014	0.575	37.00	0.0156	0.986
1.0	0.556	0.060	0.556	9.38	0.0600	0.976
1.1	0.581	0.110	0.528	5.28	0.1000	0.900
1.2	0.600	0.148	0.500	4.05	0.1241	0.735
1.3	0.611	0.188	0.470	3.25	0.1445	0.680
1.4	0.619	0.220	0.441	2.81	0.1571	0.631
1.5	0.625	0.250	0.416	2.50	0.1666	0.588
1.6	0.629	0.277	0.393	2.27	0.1731	0.548
1.7	0.630	0.301	0.371	2.09	0.1770	0.512
1.8	0.631	0.324	0.351	1.95	0.1800	0.485
1.9	0.631	0.345	0.332	1.83	0.1815	0.462
2.0	0.631	0.365	0.315	1.73	0.1825	0.443

Interpolating in Table II we obtain the corresponding values

$a = 0.564$
$b = 1.033$
$c = 0.076$

whence

$$C = \frac{b}{\omega R} = \frac{1/033}{377 \times 200} = 13\ 72\mu f$$

and

$$r = \frac{cR}{b} = \frac{0.076 \times 200}{1.033} = 14.7\Omega$$

The addition of 1.7 ohms in series with the 13 ohms of the coil satisfies this last value.

Without going into details as outlined in the previous article, it may be noted that the voltage rating of the capacitor should be at least 450 volts.

Referring again to the tables we see that the $\text{Eff}_{\text{lead}} = 0.837$ and

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RESINOX 7934
comes through under severest operating conditions

Low Water Absorption

—only 0.030% by weight after 24 hours' immersion

Low Dielectric Constant and Power Factor

Dielectric constant at 1 K.C.
—4.35 to 4.50

Dielectric constant at 1 M.C.
—4.20 to 4.50

Power factor at 1 K.C.
—0.015 to 0.017

Power factor at 1 M.C.
—0.0080 to 0.0085

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MANROSS *hairsprings*

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DIVISION OF ASSOCIATED SPRING CORPORATION

BRISTOL, CONNECTICUT

$Eff_{lag} = 0.852$. The overall efficiency of power conversion from single phase to three phase can be shown to be

$$Eff_{total} = \frac{3}{1 + (1/Eff_{lead}) + (1/Eff_{lag})}$$

which in this case gives $Eff_{total} = 89$ percent.

The required current-carrying capacity of the coils can be calculated from these efficiencies. In this case the coils would carry approximately 0.75 amperes.

It should be recalled that this analysis assumes a resistive, linear load. Possibly the most frequent application of three phase at 60 cycles is to motors where the load has a reactive component. For optimum design in this application, it is necessary to compensate each of the field windings for its inductive component at full load. The effect of the shifter on the pull-in and pull-out torques as compared with operation directly from a three-phase line awaits experimentation. That there is some effect is to be expected because the starting load differs from the running load in both effective resistance and reactance.

This method of producing three-phase power from a single-phase source can be used at frequencies other than 60 cycles; it is stable in operation under line-voltage variations or amplitude modulation of the input voltage.

• • •

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Stresses that occur in the turns of a filament are removed by applying a gas flame to the filament while being rotated in this machine at the Dobbs Ferry plant of North American Philips

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PIONEER MANUFACTURER of FM BROADCASTING EQUIPMENT LEADS AGAIN!!

REL announces it is prepared to furnish to the FM broadcast stations now on the air, power converting devices applicable to transmitters of any manufacture, which will furnish one or three kilowatts output power at any frequency in the new band (88 – 106 megacycles). This device enables the station to transmit simultaneously, in addition to its old frequency, the new frequency during the important interim period of operation.

This device requires no additional monitoring of the audio program as one monitor controlling point takes care of both frequencies.

This device furnishes you with a relatively inexpensive method of operation during the transition period.

Consult us immediately for prompt delivery of your order, pending lifting of present restrictions.

PIONEER MANUFACTURERS OF FM TRANSMITTERS EMPLOYING ARMSTRONG PHASE SHIFT MODULATION

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Long Island City, N.Y.

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NEWS OF THE INDUSTRY

Broadcast prosperity; JETEC personnel; survey notes on servicemen; fundamental research; railroad radio; meeting scheduled; Washington, FCC, business news

FCC Places F-M in 88-106 Megacycle Band

ON JUNE 27, 1945 the Federal Communications Commission issued report 83095 announcing their adoption of alternative No. 3, with certain modifications, for the much-discussed band between 42 and 108 megacycles. The unexpectedly early decision was made because of the WPB announcement that the manufacture of a-m, f-m, and television transmitters and receivers might commence at an earlier date than was originally indicated. The channel allocations are as follows:

Freq. Band	Final Proposed Allocation
42— 44 mc	Nongovernment fixed and mobile
44— 50 mc	Television—Channel No. 1
50— 54 mc	Amateur
54— 60 mc	Television—Channel No. 2
60— 66 mc	Television—Channel No. 3
66— 72 mc	Television—Channel No. 4
72— 76 mc	Nongovernment fixed and mobile
76— 82 mc	Television—Channel No. 5
82— 88 mc	Television—Channel No. 6
88— 92 mc	Noncommercial educational f-m
92—106 mc	F-m
106—108 mc	Facsimile

This allocation is essentially the allocation proposed as alternative No. 3 of the earlier report, except that the nongovernment fixed and mobile services have been moved from 104-108 mc to 72-76 mc, and f-m and television have been adjusted accordingly. The advantage of this change is that it makes possible immediately the use of all 13 television channels below 300 mc. Under alternative No. 3, as originally proposed, the entire 6-mc television channel between 72 and 78 mc could not be used until the aviation markers centering on 75 mc were moved.

The nongovernment fixed and mobile services are not under the same disability. They can use the entire band between 72 and 76 mc at once with the exception of approximately 0.5 mc in the vicinity of 75 mc to protect the aviation markers. This shift of the nongovernment fixed and mobile services from 104-108 mc to 72-76 mc also results in a possible increase in the number of channels available to these services, since a 40-kc channel is adequate in the 72-76 mc portion of the spectrum, whereas a 50-kc channel was proposed in the 104-108 mc region.

The FCC will move with all possible speed to revise present regulations and standards of good engineering practice for the operation of f-m, television and facsimile broadcasting in the new allocations. As soon as these revised rules and standards are adopted by the Commission, the industry will have all the information it needs from a regulatory standpoint to proceed with the planning and design of new receiving sets and transmitters.

When manpower and materials again become available and conditions permit the resumption of normal licensing practices, the Commision will make an appropriate announcement and will provide a period of not less than 60 days for the filing and processing of new applications prior to taking any action on the 420 f-m and 119 television applications now in its pending files. In the meantime, the Commission's staff will go through these applications and call for whatever further information may be required due to the change in bands. In the majority of cases there will be no material difference in the distances to the 50 microvolt per meter contour in either band.

Chairman Paul A. Porter recommended that f-m receiver manufacturers build sets to cover the entire band from 88 to 108 mc. This will make possible the expansion of f-m in the event facsimile is ultimately located in the 400-mc region and vacates the band 106-108 mc. Also, he took the opportunity to point out if the public is to enjoy the full capabilities of f-m, manufacturers must build receivers which will reject undesired signals and noise up to one half the strength of the desired program.

Alternatives

The other two alternatives for the disputed 44-108 mc region, along with a tabulation of all remaining allocations for that region of the radio spectrum above 25 mc, are given in the July 1945 issue of ELECTRONICS.

In the FCC hearings there was unanimity that alternative No. 2 (68-86 mc for f-m) was completely unfeasible.

The primary objection to alternative No. 1 was the amount of sky-wave interference which will result among f-m stations if f-m is placed in the 50-68 mc region. For

Building fund activities of IRE bring together in meeting these familiar figures of the industry—around the table, in rotation: Keith Henney, ELECTRONICS; Melville Eastham, General Radio; T. M. Odarenko, Federal Telephone & Radio; R. R. Batcher, Caldwell-Clements; Roger Wise, Sylvania; D. E. Noble, Galvin; W. R. G. Baker, GE; L. C. F. Horle, consultant; Ben Gross, Gross Distributors; Walter C. Evans, Westinghouse; Haraden Pratt, Mackay; L. G. Pacent, Pacent Engineering; (and against the wall) E. W. Ritter, Corning Glass; J. C. Trostle and A. L. Aderton, building fund campaign directors; H. C. Forbes, Colonial Radio; D. J. Phelps, General Instrument; L. F. Miles, Maxon; E. J. Staubitz, Blaw-Knox; and David Kahn, Radio & Television

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Regardless of your particular requirements, our specialized knowledge of UHF, plus a plant especially equipped for UHF production, should be invaluable in accomplishing your objective quickly, accurately and economically.

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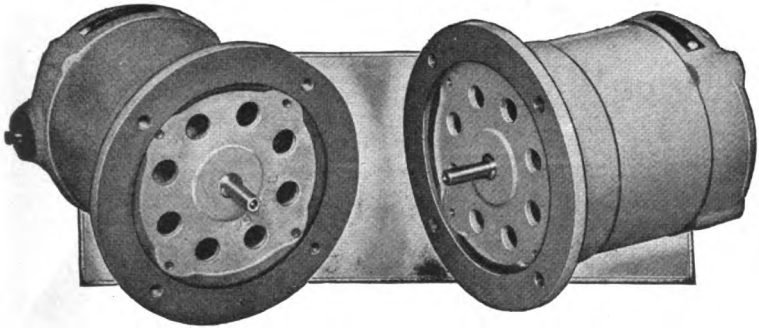

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example, interference among 50-kw f-m stations at 58 mc from sporadic E transmissions alone, assuming a 10:1 ratio of desired to undesired signal and full occupancy of the channel, might be expected for 140 to 480 hours per year at the 50-microvolt contour from stations 900 and 1000 miles distant, respectively. At 84 mc, in contrast, interference under these conditions would be anticipated for only 6.5 to 25.5 hours per year. It should be noted that the 140-480 hours per year of anticipated interference would not be spread out evenly throughout the entire year, but would be concentrated in two or three summer months.

In addition, interference from F_2 transmission at 53 mc may be anticipated for as many as 470 hours per sunspot cycle, concentrated in a period of three years in the case of a suspot cycle the same as the last one, or interference may exist for as much as 2,650 hours per sunspot cycle if the next sunspot cycle is as severe as the highest on record. These figures assume only two stations on a channel; more than two would double or treble the number of hours during which F_2 interference would be expected at 53 mc.

Practical Conditions

These interference figures mean, for example, that a listener tuned to a station which is carrying the program of his choice may suddenly find either that the program to which he has been listening is being interfered with by a station hundreds or even thousands of miles away, or else that control of his receiver has been seized altogether by a distant station, completely obliterating the desired programs despite anything he does to the tuning controls.

It has been argued that the bulk of the interference anticipated will be found in outlying rural areas which rely upon low-intensity signals for their radio reception and that if these areas be excluded, f-m service will be more than 99-percent perfect. The Commission, however, is under a statutory duty to make available to *all* the people of the United States an efficient nationwide radio service. The Commission's duty is not fulfilled if its

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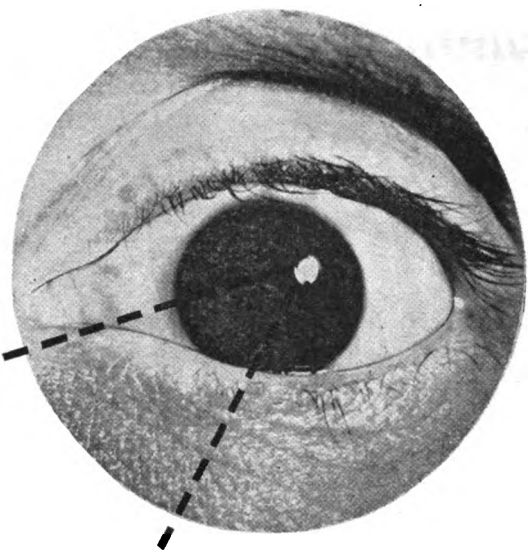
LOOK to BEST



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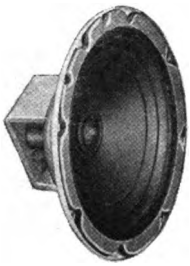

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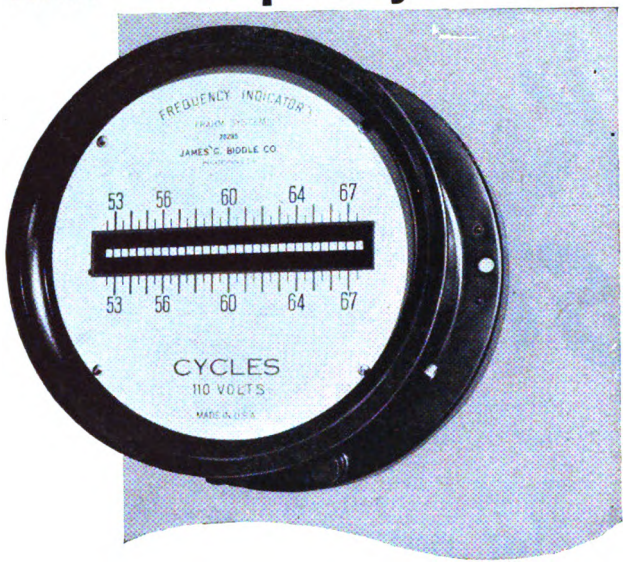
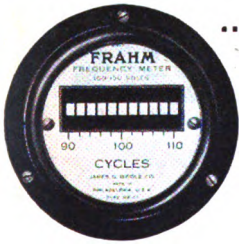
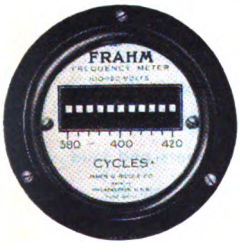
"FRAHM" Frequency Meters



What are your Frequency Measuring Requirements ...25...60...100...400.....1400 cps?





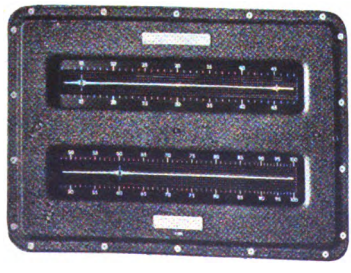
Frahm Frequency Meters in switchboard, miniature and portable types are regularly available for ranges between 15 and 500 cycles per second.

To meet special requirements, our laboratory has designed and built instruments for measuring frequencies as high as 1400 cycles. Such, we find, is possible by means of the same simple and direct resonant reed principle, usually requiring less than 0.1 volt-ampere power input, and without recourse to inter mediate frequency conversion equipment. We believe that even higher frequencies are possible.

We invite correspondence regarding any frequency measurement problem in the audio and sub-audio range. For its solution we proffer our instruments, our services and facilities. In our 30 years of association with the resonant reed principle as applied to the measurement of frequency, we have been instrumental in the solution of a surprising variety of problems.

Write for Bulletin 1770-E now in preparation.

This instrument was developed for direct indication of frequencies in the lower audio range and for simultaneous direct indication of harmonic components. Called a Harmonic Analyzer, it has unusual electrical characteristics and a wide range, with a total of 288 reeds.



JAMES G. BIDDLE CO. 1211-13 ARCH STREET PHILADELPHIA 7, PA.

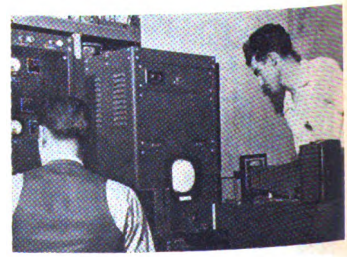
provision for f-m service is such as to make it impossible for rural areas to enjoy satisfactory service.

Various objections to assigning the higher frequencies to f-m have been raised. For example, it has been alleged that tropospheric interference may be worse in the vicinity of 100 mc than in the 50-mc region. The Commission in its report of May 25, 1945, specifically pointed out that there would be some difference in tropospheric propagation, but this difference would be only slight and that tropospheric interference at the higher frequencies could be eliminated by slightly increasing the geographical separation between stations.

Cost

The point has also been made that equipment for use in the vicinity of 100 mc will cost more than equipment for use in the vicinity of 50 mc. This will no doubt be true at least temporarily, but competition should reduce the differential substantially, and the Commission believes the benefit to the public resulting from an interference-free service will more than outweigh the slight increase in initial cost for service in the 100-mc region.

Much emphasis was placed at one time on the presumed hardship which would result to the approximately 400,000 persons who had purchased f-m receivers before the war. Most of these receivers are combination a-m/f-m and the a-m part of the receiver will continue to be used. There is now substantial



At the right a photographer takes directly from the cathode-ray screen a record of the characteristic curve of an electron tube being tested at the left. Equipment, developed by engineers of Sylvania Electric Products Inc., speeds to designers in a matter of minutes vital information which would require many man-hours if done by conventional methods

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A perfect complement for the Brush Surface Analyzer is the new Rough-Finish Measuring Head. Developed to meet the growing need for the checking of rougher surface finishes and waviness, it accurately measures irregularities from 100 to 3,000 microinches, peak to valley.

This new Pickup (Model BL-101) and Drive Head (Model BL-102), when used with the Brush Surface Analyzer, extend its usefulness and range of measurement from 1 to 3,000 microinches.

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agreement that the 42-50 mc band for which these receivers were made is wholly inadequate and unsuited to f-m reception. Accordingly, no one today argues that postwar f-m should be degraded to the point necessary to accommodate these receivers. However, interim operation in the present band from 42 to 44 mc is being provided until such time as equipment for the higher frequencies is freely available to the public and until owners of existing receivers have had equal opportunity to adapt or convert them to the new band. In this connection, a converter was demonstrated to the Commission which would make existing f-m receivers capable of tuning to the higher frequencies and which should retail for approximately $10.00.

Bretton Woods & Good Business

HEADED BY Ralph E. Flanders of Jones and Lamson Machine Co., a so-called Business and Industry Committee for Bretton Woods is supporting those agreements as a basis for postwar prosperity through international trade. One of a special series of reports issued by the committee deals with the effect of Bretton Woods on the electronics industry. Copies can be obtained from the committee headquarters in the Roosevelt Hotel, New York 17, N. Y.

Electronics in a Saxophone Factory

VACUUM TUBE APPLICATIONS involving a number of different factory operations at the plant of C. G. Conn Ltd. were recently described by director of engineering research E. L. Kent at a Cedar Rapids, Iowa, section meeting of IRE.

Summarized, the uses included: a smoke alarm control system which used a phototube to reduce the bias on a blocking oscillator and allow a tone to be heard which rose in pitch as the smoke intensified; a dynamic balancing unit for gyro rotors which utilized an electronic wattmeter with a reference signal from a phototube applied to one section while the vibration signal entered the other input terminals; a device for measuring speed of

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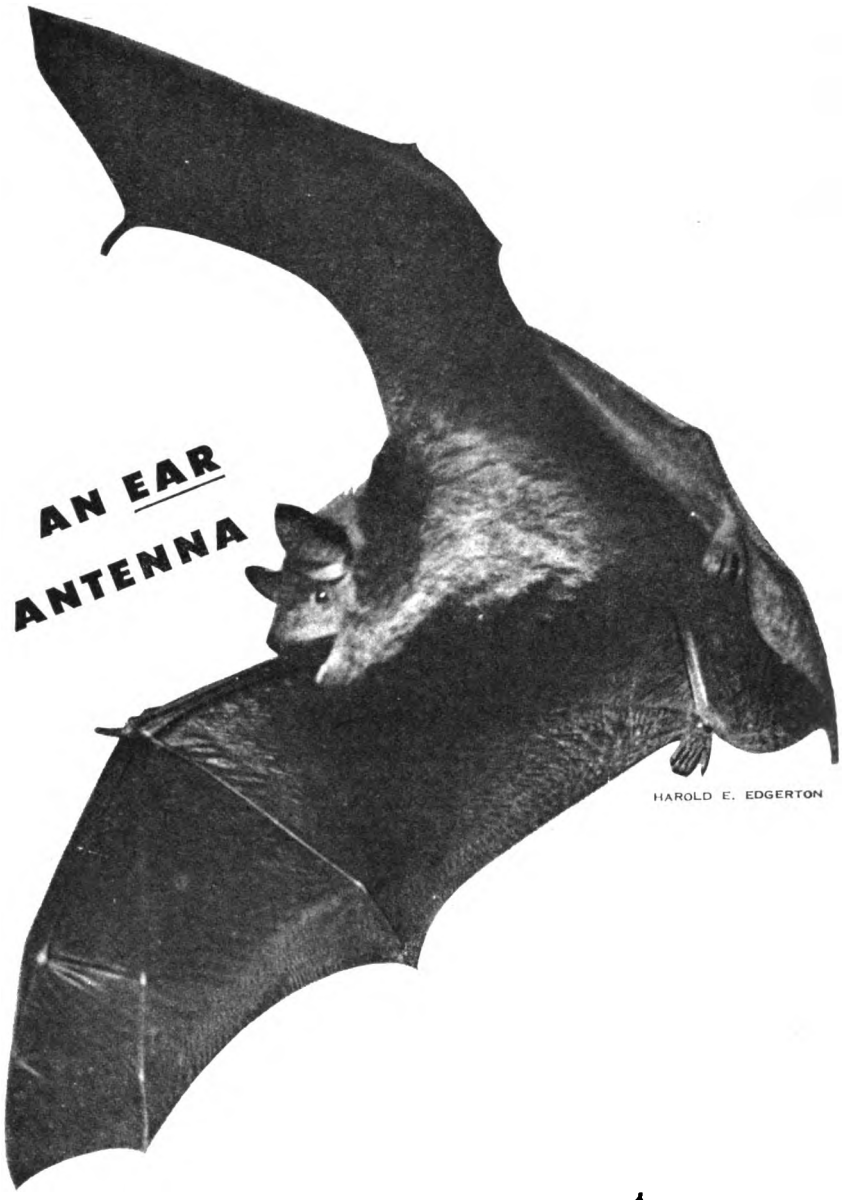
AN EAR FOR AN ANTENNA



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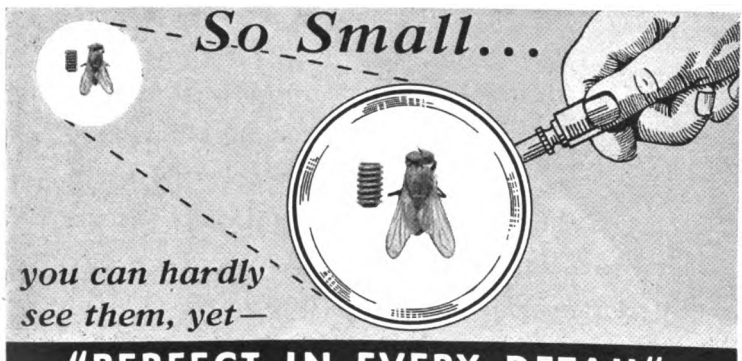

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Sizes from #0 to 1" diameter—all commercial lengths.

Where the Knurled Cup Point "Unbrako" cannot be used, use our Knurled Thread "Unbrako"—also a Self-Locker regardless of the style of point.

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superchargers, which accommodated magnetic, electrostatic or photoelectric pickups with frequency dividers which were used to drive a synchronous motor powering the final Kollsman tachometer; a unit to determine the bearing loading in gyro flight instruments which measured the speed of the rotor, its negative acceleration when coasting, and vibration when rotating at high speed; and a chromatic stroboscope which measured speed or frequency of various pieces of equipment, by converting the alternating quantity to be measured into an audio signal which was fed to a discharge tube producing flashes of light to illuminate a series of stroboscopic disks rotating at various speeds.

The Broadcast Business

FINAL FIGURES from FCC show that the 836 standard broadcast stations reporting had a 1944 income of $68,888,110; 47 percent above 1943 and 125 percent over 1942. Average income per station rose from $36,488 in 1942 to $55,948 in 1943 to $82,402 in 1944.

In the power category from 1 to 2½ kw, 137 commercial broadcast stations of the nation's 162 had net time sales for 1944 which were 41 percent above 1943. All but two reported increases. In the bracket between 5 and 20 kw, 191 of the nation's 225 standard broadcast stations netted an increase of 28 percent, with increases by all. For 383 of the 446 standard broadcast stations operating between 200 and 500 watts of power, the increase was 40 percent over corresponding figures the year before.

JETEC Chairmen

PRELIMINARY ORGANIZATION of the Joint Electron Tube Engineering Council, cooperatively sponsored by RMA and NEMA, results in appointment of the following committee chairmen: pool tubes, D. E. Marshall Westinghouse Electric; high-vacuum power tubes, K. C. DeWalt, General Electric; cathode-ray tubes, Irving Lempert, Allen B. Du Mont Laboratories; vacuum sealed devices, M. A. Acheson, Sylvania Electric Products; receiving

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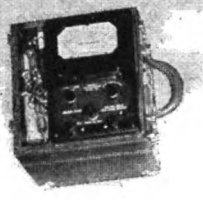
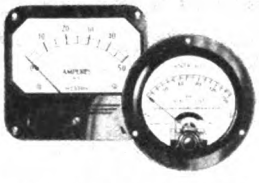
(MODEL 785) INDUSTRIAL CIRCUIT TESTER . . . the most versatile portable tester for laboratories, and plant maintenance, where an ultra-sensitive instrument is required. Provides 27 AC and DC voltage, AC and DC current, and resistance ranges. (dc sensitivity 20,000 ohms per volt.)



(MODEL 796) INSULATION TESTER . . . a direct-reading self-contained resistance tester that eliminates hand cranking. Tests up to 200 megohms at test potential of 350 to 500 volts dc., current at terminals only a few microamperes. Ranges 0-20-200 megohms, full scale . . . 0-.5-5 center scale.

(MODEL 697) VOLT-OHM-MILLIAMMETER . . . combines a selection of AC and DC voltage, direct current, and resistance ranges in a pocket-size meter. Ideal for maintenance testing and inspection needs.

(MODEL 633) AC CLAMP AMMETER . . . for quick, easy current measurements on insulated or non-insulated conductors. The clamping jaws are simply clamped around the conductor, and readings taken. Circuits are never disturbed. A real time saver in electrical maintenance.



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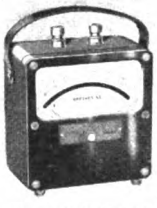

(MODEL 430) AC AND DC TEST INSTRUMENTS . . . combine dependability, ruggedness, compactness and scale readability. Equipped with hand calibrated, mirror scales. Available for AC and DC requirements, and as DC and single-phase AC Wattmeters.

(MODEL 703) SIGHT METER . . . direct-reading, pocket size meter calibrated to measure light values in foot-candles, or by seeing tasks. Equipped with the WESTON VISCOR* filter, it measures all light values direct, without correction factors.

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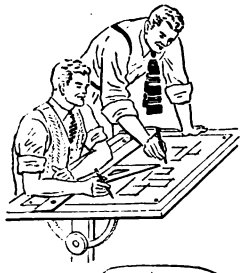
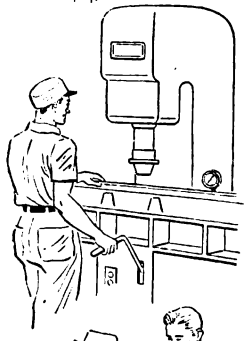
electrical sheets and strip for every requirement



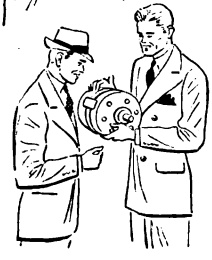
FOR YOUR DESIGNERS

—Silicon steels which possess the precise magnetic characteristics desired for specific electrical and electronic applications.



FOR YOUR PRODUCTION MEN

—Electrical Sheets or Strip which meet high standards of punching quality, surface finish, gauge and space factor.



FOR YOUR CUSTOMERS

—Silicon steels which function properly, which lend themselves to smooth production, make an important contribution to your manufacture of products that perform as designed . . . and which thus win the favor of customers.

★ *When placing your next order for Electrical Sheets or Strip, check with Follansbee . . . for years a leader in this field.*

FOLLANSBEE STEEL CORPORATION

GENERAL OFFICES • PITTSBURGH 30, PA.

Sales Offices—New York, Philadelphia, Rochester, Cleveland, Detroit, Milwaukee. *Sales Agents*—Chicago, Indianapolis, St. Louis, Kansas City, Nashville, Houston, Los Angeles, San Francisco, Seattle; Toronto and Montreal, Canada. *Plants*—Follansbee, W. Va. and Toronto, Ohio

ALLOY BLOOMS & BILLETS, SHEETS & STRIP • COLD ROLLED CARBON SHEETS & STRIP
POLISHED BLUE SHEETS • ELECTRICAL SHEETS & STRIP • SEAMLESS TERNE ROLL ROOFING

tubes, A. K. Wright, Tung-Sol Lamp Works; phototubes, A. M. Glover, RCA, Lancaster; gas tubes, S. B. Ingram, Bell Telephone Labs.; type designations, R. S. Burnap, RCA; mechanical standardization, E. F. Peterson General Electric; packaging, R. S. Bolan, Raytheon Mfg.; and sampling procedure, S. W. Horrocks, RCA, Lancaster.

Drafting Standards

AT THE REQUEST of WPB, the American Standards Association (ASA) is working on a series of American War standards for drawing and drafting room practice. The objective is to correlate techniques of the Army and Navy with those of industry and should result in great economies. One large company reports that it has more than a dozen engineers presently working on the complicated problem of setting up drafting standards between subcontractors and divisions of its own organization.

Scope of the work will include civil, mechanical, electrical, areonautical, and marine engineering and will cover abbreviations; methods of indicating and specifying threads; methods of lettering; forms and sizes of drawings; graphical, diagrammatic, and schematic symbols; methods of indicating and specifying materials and finishes; methods of dimensioning, numbering, and indicating tolerances.

Ersatz Activities

MANY STRATEGIC MATERIALS have been supplanted by substitutes devised and developed by the U. S. Army Signal Corps, according to a recent announcement. Some of these include: low grade mica for low voltage capacitors, plastic insulation for wires, magnesium for chassis and antenna masts, plasticized ceramics as a mica substitute in capacitors, glass for insulators, rubber substitutes for vibration isolators, and meteorological balloons.

Chile Station

STATION CB114, shortly to go on the air with the Andes as a backdrop, will be the first long-wave broadcast station to reach throughout the curving 2600-mi. length of

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Avoid Moisture Damage in Over-Seas Packages

Simply put a few small bags of Jay Cee Silica Gel, like the ones above, inside your container . . . wrap or seal tightly . . . and ship over-seas without fear of damage from "in-the-package" moisture. Jay Cee Silica Gel is an ideal drying agent . . . has amazing power to absorb atmospheric moisture. Thus the air inside of containers is kept absolutely dry and delicate metal parts are protected from rust and corrosion.

Jay Cee Silica Gel is also used in packages of foods, fabrics, chemicals, and other products. Moreover, it has wide application in the air conditioning, refrigeration, and chemical industries. Jay Cee Silica Gel is clear white; passes a rigid section test; meets exacting Government specifications; is strictly a quality product.

JOBBERS WANTED — There are excellent opportunities for jobbers to build profitable business on Jay Cee Silica Gel in a few territories. Write for details.

JOLIET CHEMICALS, LTD., INDUSTRY AVENUE, JOLIET, ILLINOIS

JAY CEE

SILICA GEL

A superior dehydrant

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PUSH BUTTON • ROTARY
AND TOGGLE SWITCHES
For Low Voltage Applications

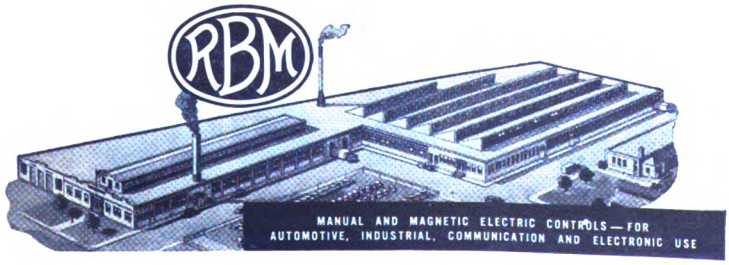
No. 71100. Push button single pole normally open. Rating—60 watts. Mounting—threaded bushing.

No. 71500. Rotary type single pole with 10 ohm variable series resistor. Screw mounting.

No. 71510. Push-pull type single pole single throw. Rating—30 watts. Mounting—threaded bushing.

Here is a representative group of the extensive line of R-B-M electric control accessories... push button, rotary, and toggle switches; slow make-and-break contacts... now available for general purpose low voltage applications. Maximum rating, 32 volts, A. C. and D. C. For complete specifications, write Department A-8....

R-B-M MANUFACTURING COMPANY
Division of
ESSEX WIRE CORPORATION
LOGANSPORT, INDIANA



Chile from Arica to Punta Arenas.

Designed to operate with 50 kw of power, the station was planned and built by Corporación de Radio de Chile, manufacturing subsidiary of RCA in Santiago.

Coverage is possible through the use of a special-type directional antenna and an elaborate ground system which act in concert to produce an unmodulated carrier power of almost 140 kw to the north and south. Frequency, as signified by the figures in its call letters, is 1140 kc. Seven miles from downtown Santiago, the transmitter is fed from studios in the city itself.

Electronic Education

A $5 MILLION PROGRAM for a Communications Institute of Arts and Sciences has been approved by the Trustees of Western Reserve University. To be located in Cleveland, Ohio, the building has already been designed. Costing $2 million it will cover almost an acre of ground, be three stories high, and be on a more elaborate scale than any theater in existence.

Big-Voice Anniversary

The year 1945 marks the 30th anniversary of the electro-dynamic loudspeaker and the public address system both devised by Edward S. Pridham and P. L. Jensen, a couple of engineers working on a new wireless system. It was by accident that a special model of a wire galvanometer they were working on turned into a moving-coil telephone receiver, and another chance experiment performed by adding to this unit the horn from an Edison phonograph produced the first loudspeaker — immediately christened Magnavox as the basis for the present company of the same name. This first unit transmitted music and speech heard 4½ miles away.

Service Orchids

BY AND LARGE, according to a recent survey, the radio repairmen of the country have been doing a good job.

Executed for Sylvania Electric Products, the investigation revealed that there are approximately 24,700 radio service establishments in the United States, employing 60,000 people with specialized skills,

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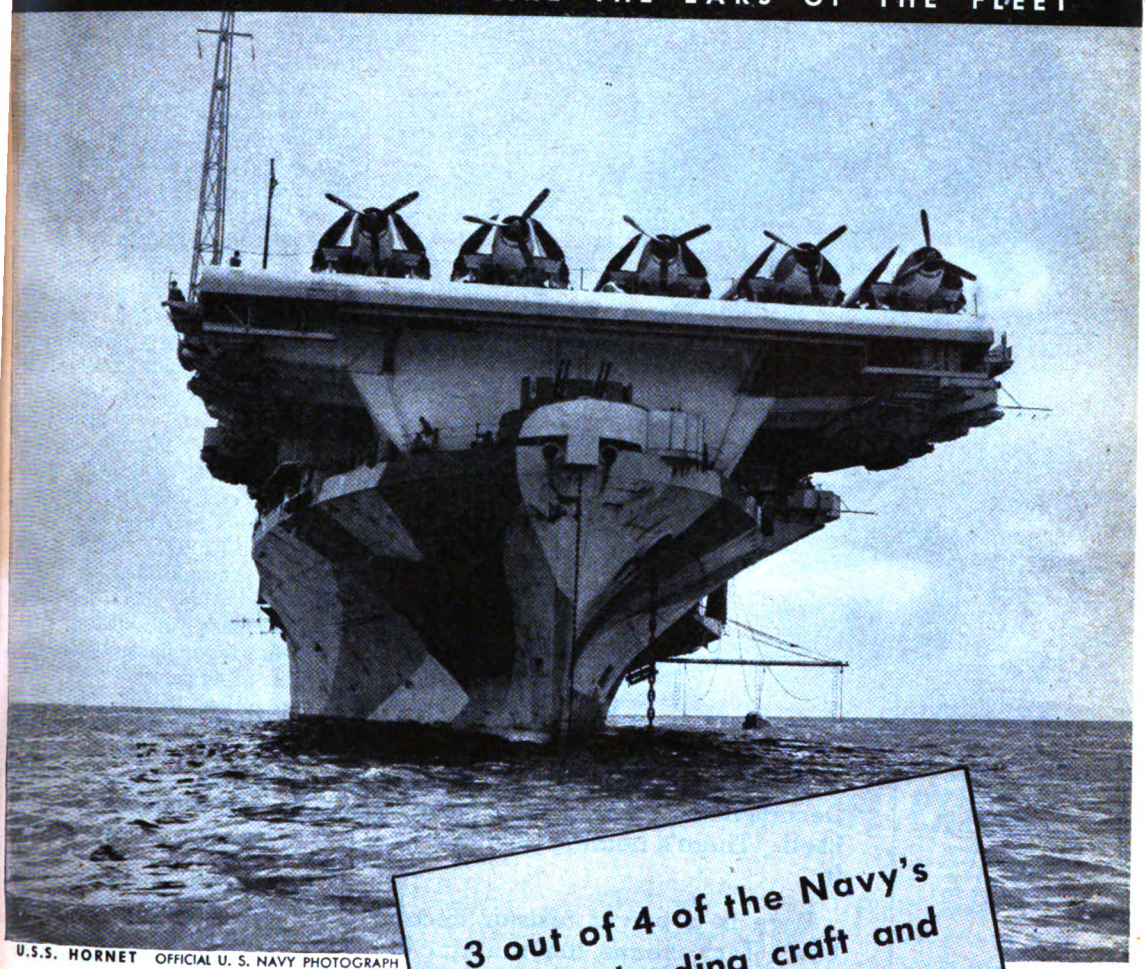
NATIONAL RECEIVERS ARE THE EARS OF THE FLEET



U.S.S. HORNET OFFICIAL U. S. NAVY PHOTOGRAPH

3 out of 4 of the Navy's ships—landing craft and larger—use receivers designed by National.

A capital ship is no place to use anything but the finest in radio equipment.

HRO

NC-200

NATIONAL COMPANY

MALDEN MASS, U. S. A.

NATIONAL RECEIVERS ARE IN SERVICE THROUGHOUT THE WORLD

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POWER RESISTOR DECADE BOX

ARMY E NAVY

★ Covers resistance range of 1 ohm to 999,999 ohms.

★ Each decade dissipates up to 225 watts. Greenohms (wire-wound cement-coated power resistors) used throughout. Glass-insulated wiring.

★ Six decade switches on sloping panel.

★ Maximum current per decade: 5, 1.5, .5, .15, .05 and .005 amp.

★ Attractive frosted-gray-metal case. Etched black-and-aluminum panel. Dual binding posts for left- and right-hand duty.

★ Grille at bottom, and louvres at side for adequate ventilation. Baffle plate protects switch mechanism against internal heat.

★ 13" long, 8½" deep, 5¾" high. Weight, 11 lbs.

★ This Clarostat Power Resistor Decade Box is definitely in a class by itself. There's nothing else just like it.

Here is a *power resistor* decade box. That means the introduction of the correct resistance value into any circuit or for any application, for use under actual working conditions, at the mere twist of the knobs. The resistance providing the correct operating conditions is then read directly off the dials.

No calculations required. No guesswork. No time-consuming routine. The Clarostat Power Resistor Decade Box pays for itself in short order.

★ **Literature on request.**

CLAROSTAT *Controls and Resistors*

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N.Y.

capable in over 90 percent of the cases of modifying circuits due to wartime scarcities. Nine out of ten changes were reported to be successful.

Specifically, it was discovered that about 40 percent of all radio repairs can be made with either tubes alone, with mechanical or electrical parts alone, or labor alone; 36 percent requiring two of these factors; 17 percent requiring three, and only 7 percent requiring four. Stated in other words, 52 percent of all repair jobs require tubes, 63 percent require electrical parts, and 31 percent require mechanical parts.

Servicemen contacted pointed out that sets failed through the fault of seven specific components in this order; tubes, capacitors, power supplies, tuning systems, i-f coils, r-f coils and filters. Interestingly enough, although tubes led the list, humidity, which does not affect them seriously, was cited as a major cause for radio servicing in an average of 44 percent of sets needing attention. Regional variations in the importance of humidity ran as follows: Pacific States 22 percent; East North Central States, 28 percent; South Atlantic States 61 percent, and Gulf States 67 percent.

Prewar, radio repair outlets sold 30 million tubes annually, but most of the servicemen feel there were too many types required and for this problem they blame the set manufacturers. While 54 percent of all servicemen stock 250 tube types, 38 percent stock 300, and 20 percent stock at least 400; 94 per-

Department store executives from major stores of the Gimbel Brothers chain watch camera scenes on the monitor board at General Electric's television station WRGB. The store people were inspecting facilities with an eye to training of sales personnel and for employee entertainment as well as for use as an advertising medium

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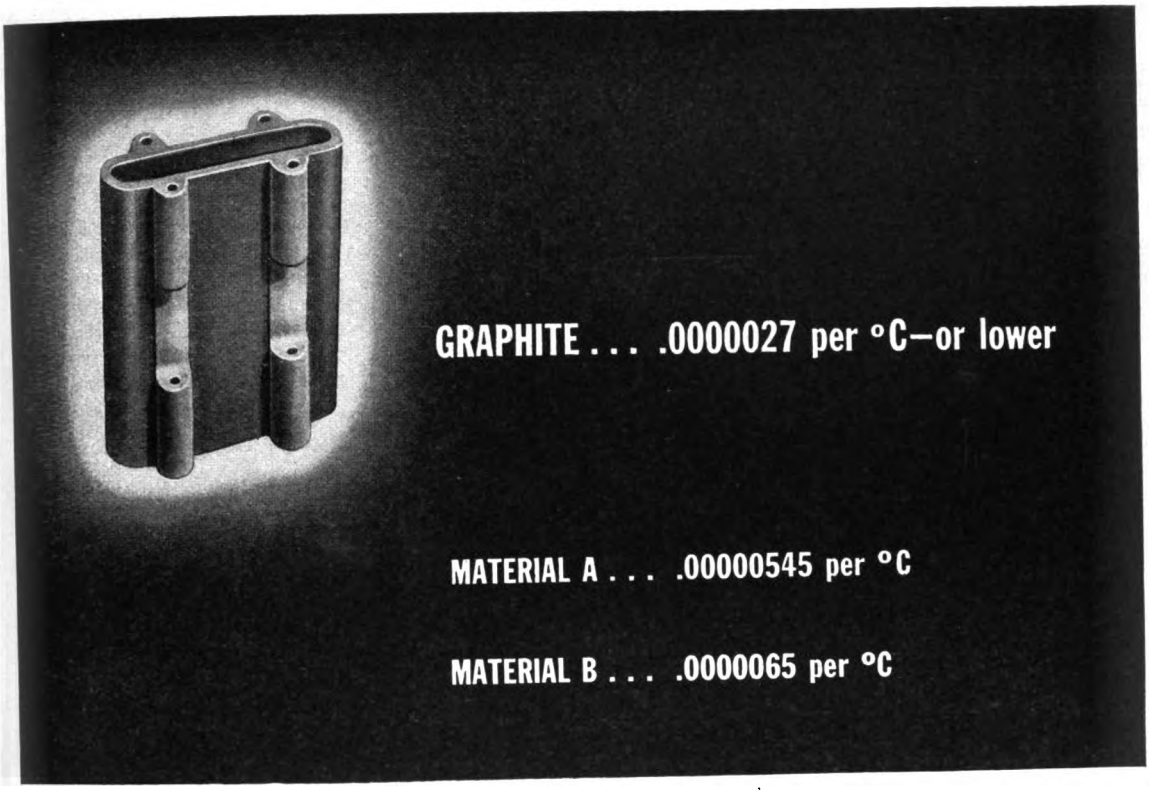

. . . COMPARE GRAPHITE'S COEFFICIENT OF EXPANSION!

The coefficient of expansion of "National" High Purity Graphite is approximately one half that of the next best electronic-tube anode materials. This coefficient is virtually constant up through temperatures far in excess of a tube's peak operating range.

The relatively low coefficient of expansion of "National" graphite anodes assures greater stability of form at maximum tube temperatures.

Furthermore, because graphite anodes carry off heat rapidly, other tube components are far less apt to warp or change their positional relationship. And the anodes themselves, even when of large area, are safe from local overheating.

The newest grades of "National" Electronic Graphite possess much greater strength, finer grain structure, smoother machined or machinable surfaces, in addition to greatly increased erosion resistance.

We welcome the opportunity to discuss with engineers and manufacturers the many advantages of "National" Electronic Graphite for both small and large tube components.

The word "National" is a registered trade-mark of National Carbon Company, Inc.

Let's get the Jap—and get it over!

★ BUY UNITED STATES WAR BONDS ★

NATIONAL CARBON COMPANY, INC.
Unit of Union Carbide and Carbon Corporation
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General Offices: 30 East 42nd Street, New York 17, N. Y.
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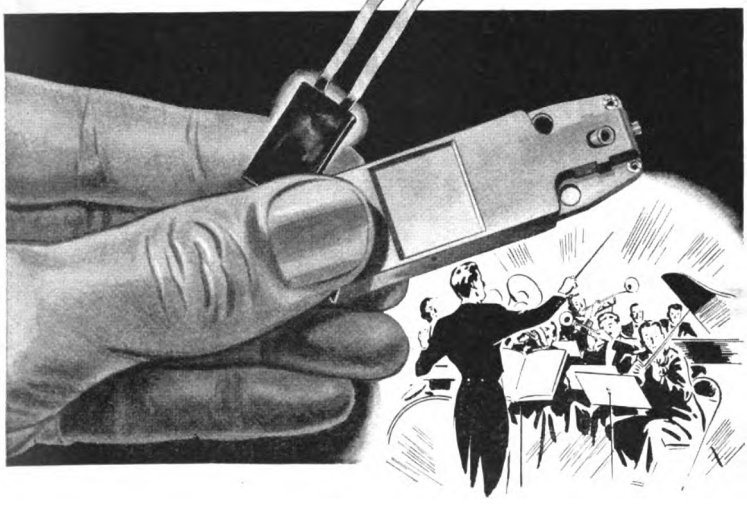
Weighs less than an ounce . . . but releases the whole world of *Glorious Recorded Music!*



NO fully satisfactory recorded sound can issue from a radio-phonograph speaker unless it is "picked up" with the utmost accuracy . . . the truest fidelity . . . by the tiny, sensitive, featherweight pickup—the true heart of record reproduction.

That is why so many makers of the highest quality radio-phonograph combinations build Webster Electric Pickups into their original equipment. Webster Electric Crystal Pickups—backed by vast engineering experience and skill in the field of sound reproduction—possess remarkable range, precise balance for the right needle pressure, light weight, most modern styling . . . The most critical music lovers appreciate the rich tonal color, the delicacy of shading, the utter faithfulness of reproduction which Webster Electric Pickups give.

You will want to know all about Webster Electric Pickups, and how they can be of value in the development of your new products and equipment. Write us for full information today.

Let's All Back the Attack
Buy Extra War Bonds

(*Licensed under patents of the Brush Development Company*)

WEBSTER ELECTRIC

Racine, Wisconsin, U.S.A. • Established 1909 • Export Dept.: 13 E. 40th Street, New York (16), N.Y.: Cable Address "ARLAB" New York City

"Where Quality is a Responsibility and Fair Dealing an Obligation"

cent said there should be fewer. 89 percent thought there should be less than 200, 79 percent less than 150, and 65 percent thought 100 would be enough.

The average serviceman was shown to stock 2.8 brands of tubes, distributed in this order of importance: RCA, Sylvania, Philco, Tung-Sol, National Union and Raytheon. 58 percent stated that quality and performance were the prime reason for brand preference. Between glass and metal types, 75 percent preferred the former.

Phonograph Upsurge

AROUND CHICAGO, investigator working for the *Tribune* uncovered a big postwar demand for phonographs and radio-phonograph combinations.

With the objective of anticipating postwar demand among the 2,232,363 urban families in the area, the survey reveals purchases of 7.1 percent or 158,498 units during the first postwar year. Extended at an average unit price of $224.73 this represents a dollar volume of $35,619,256. Figures, which are being used by John Meck Industries to plan their postwar radio-phonograph production, also show that 87.7 percent of the local owners of radios did not have phonograph facilities.

Foresters and Relay Sites

FOREST SERVICE PERSONNEL will cooperate with FCC in determination of factors affecting the selection of radio relay station sites. Working on the assumption that applications for sites will be received in increasing numbers, the two government agencies have established a joint procedure.

This will take the form of (1) examining the site to determine whether its occupancy can be authorized without conflict with the national forest or public interest; (2) indicating that such a permit would be contingent upon FCC station-approval; (3) making a report on site and other similarly useful available spots in the general vicinity; and (4) transmitting memoranda to FCC which will aid in the action to be taken.

Final permit will be given on the basis of conformity with regula-

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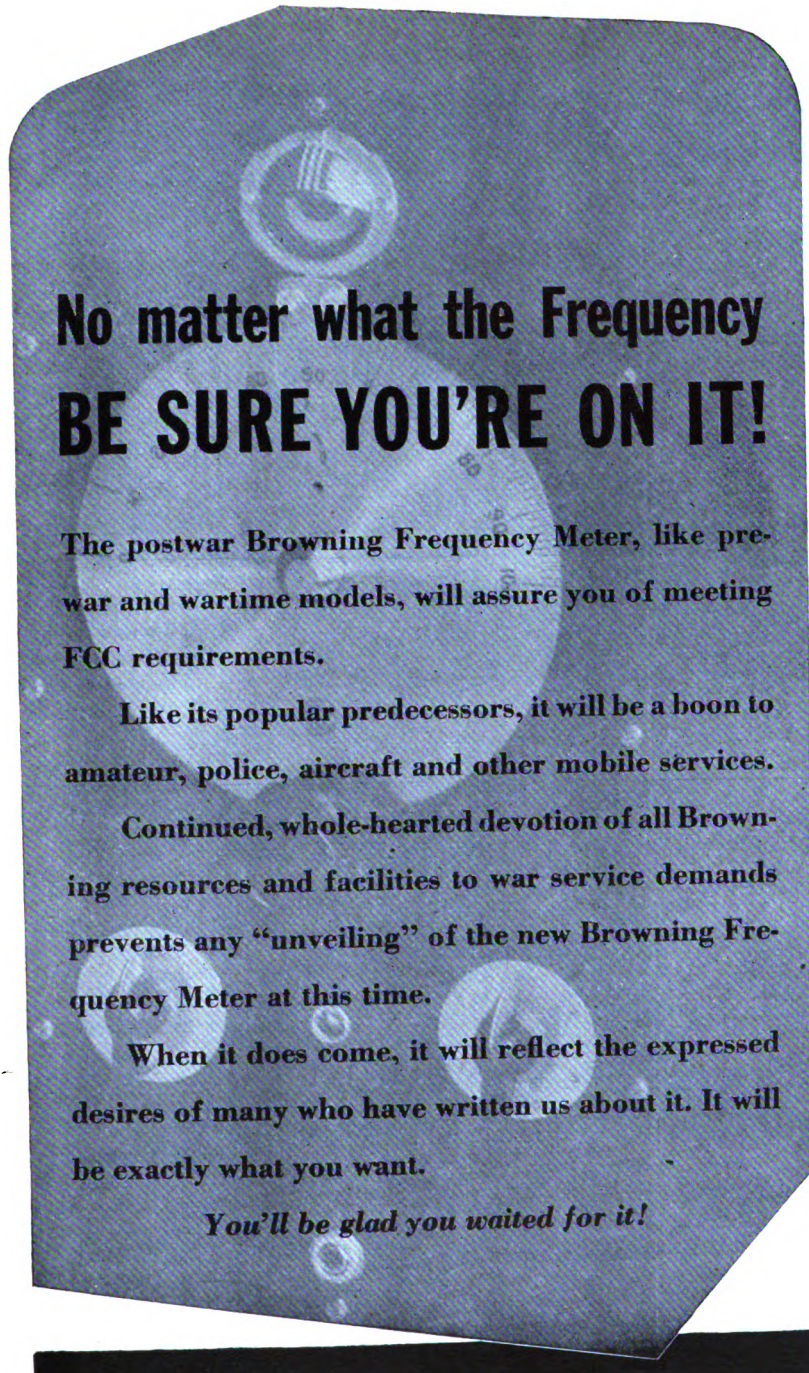

No matter what the Frequency BE SURE YOU'RE ON IT!

The postwar Browning Frequency Meter, like prewar and wartime models, will assure you of meeting FCC requirements.

Like its popular predecessors, it will be a boon to amateur, police, aircraft and other mobile services.

Continued, whole-hearted devotion of all Browning resources and facilities to war service demands prevents any "unveiling" of the new Browning Frequency Meter at this time.

When it does come, it will reflect the expressed desires of many who have written us about it. It will be exactly what you want.

You'll be glad you waited for it!

BROWNING

LABORATORIES, INCORPORATED
WINCHESTER, MASSACHUSETTS

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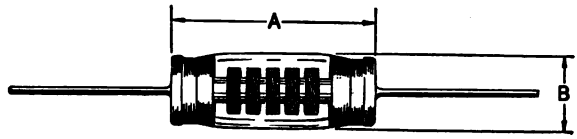
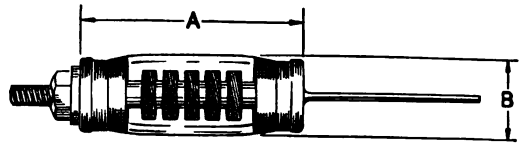
HANOVIA

HERMETICALLY SEALED

R. F. CHOKES



MILLI-HENRIES	A	B
1.0	1-3/4"	5/8"
2.0	1-3/4"	5/8"
2.5	2"	5/8"
5.0	2"	11/16"
10.0	3"	11/16"



AVAILABLE IN ABOVE TWO FORMS
RATED AT 125 M.A. FOR ALL SIZES

Complete information on these and other Hanovia Chokes on request.

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Industrial Division

Dept. E-15 **Newark 5, N. J.**

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"I SEE IT CLEARLY, GENTLEMEN... COILS... COILS... COILS ...IT IS ALBION THAT CAN SHIP ALL YOU NEED."

SUPER-QUALITY COILS AT REASONABLE PRICES

More and more every day, the industry is turning to Albion for fast, quality and quantity production of coils, chokes, and transformers. That's because here you benefit from the unbeatable combination of management "know how," skilled workmanship, streamlined facilities, and central location. Your requirements will be given prompt and thoughtful attention.

ALBION
COIL COMPANY

ALBION, ILLINOIS

R. F. AND TRANSMITTING COILS AND CHOKES, I. F. TRANSFORMERS

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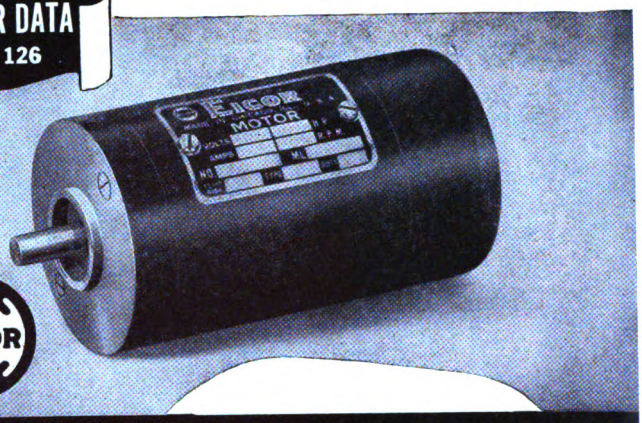
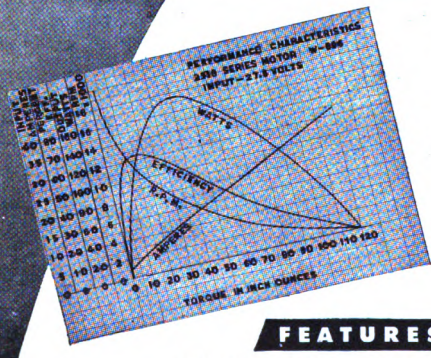
MOTOR DATA
No. 126



EICOR

2300 FRAME MOTOR

1/5 HP at 3800 RPM



The basic design of the 2300 Frame Motor has been used in scores of individual modifications. Many of these designs are complete and available—others for new equipment can readily be developed.

FEATURES

ELECTRICAL

Series or shunt wound
High starting torque
Low starting current
High efficiency
Low RF interference
Unidirectional or reversible
Armature and field windings varnish impregnated and baked

MECHANICAL

Low weight factor
Unusual compactness
Completely enclosed
Base or flange mounting
Laminated field poles
Precision ball bearings
Segment-built commutator
Permanent end play adjustment

2300 FRAME MOTORS		2318 Series	2310 Shunt
Watts Output, Int.	(max.)	160	50
Torque at 6000 RPM	(in. oz.)	40	10
Torque at 3800 RPM	(in. oz.)	57	—
Lock Torque	(in. oz.)	120	14
Volts Input	(min.)	5	5
Volts Input	(max.)	110	28
Temperature Rise	(int.)	50°C	50°C
Diameter		$2\frac{5}{16}$"	$2\frac{5}{16}$"
Length less shaft		$4\frac{5}{32}$"	$2\frac{3}{4}$"
Shaft Dia.	(max.)	.312"	.312"
Weight	(lbs.)	2.4	1.5

EICOR INC. 1501 W. Congress St., Chicago, U.S.A.

DYNAMOTORS • D. C. MOTORS • POWER PLANTS • CONVERTERS

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LONG SCALE, WIDE RANGE VOLT-OHM-MILLIAMMETER

DOUBLE SENSITIVITY
D. C. VOLT RANGES
0-1.25-5-25-125-500-2500 Volts, at 20,000 ohms per volt for greater accuracy on Television and other high resistance D.C. circuits.
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

A. C. VOLT RANGES
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

OHM-MEGOHMS
0-400 ohms (60 ohms center scale)
0-50,000 ohms (300 ohms center scale)
0-10 megohms (60,000 ohms center scale)

DIRECT READING OUTPUT LEVEL DECIBEL RANGES
−30 to +3, +15, +29, +43, +55, +69 DB

TEMPERATURE COMPENSATED CIRCUIT FOR ALL CURRENT RANGES D.C. MICROAMPERES
0-50 Microamperes, at 250 M.V.

D. C. MILLIAMPERES
0-1-10-100-1000 Milliamperes, at 250 M.V.

D. C. AMPERES
0-10 Amperes, at 250 M.V.

OUTPUT READINGS
Condenser in series with A.C. Volts for output readings.

ATTRACTIVE COMPACT CASE
Size: 2½" x 5½" x 6". A readily portable, completely insulated, black, molded case, with strap handle. A suitable black, leather carrying case (No. 629) also available, with strap handle.

LONG 5" SCALE ARC
For greater reading accuracy on the Triplett RED ● DOT Lifetime Guaranteed meter.

SIMPLIFIED SWITCHING CIRCUIT
Greater ease in changing ranges.

Write for descriptive folder giving full technical details

STANDARDS ARE SET BY TRIPLETT

Precision first ...to last

Triplett

ELECTRICAL INSTRUMENT CO. BLUFFTON, OHIO

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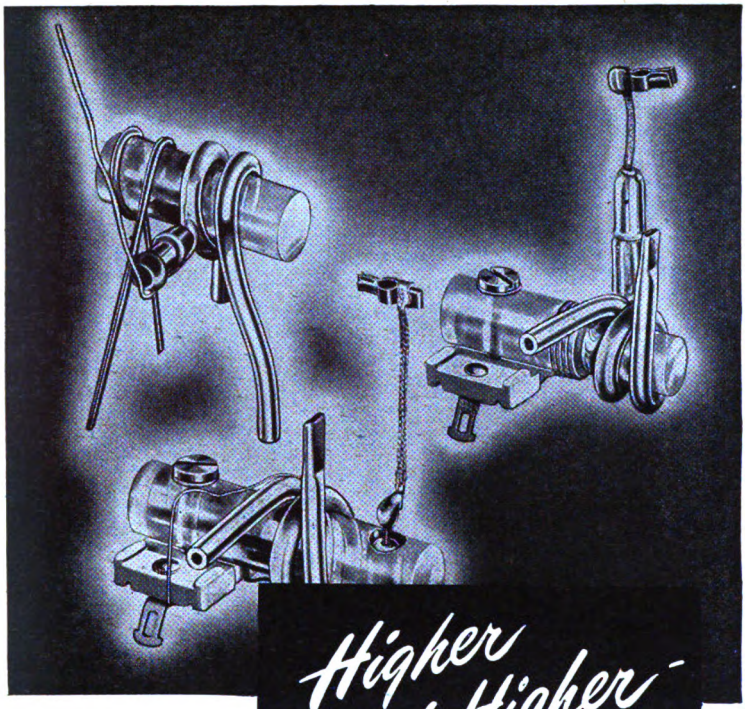

Electronic Winding Co. has developed special high quality coils for Ultra High Frequency work. Development of our coils has kept pace constantly with the development of high frequency communications equipment and out of our intensive war experience will come a new and finer product ready to do a new and finer job on the rapidly expanding frontiers of radio communications.

Electronic Winding Co.

5031 BROADWAY
CHICAGO 40, ILL.

★ ★ MANUFACTURERS OF EXTRA QUALITY COILS FOR PRECISION COMMUNICATIONS EQUIPMENT

allow room for expected expansi during the next 20 years. The co pany has about twenty other labo atories, but these are for develo mental and product research.

MEETINGS TO COME

NO CONFERENCE. Due to existin restrictions and difficulties co nected with travel, the second a nual National Electronics Confe ence, originally planned for 194 will not be held. Present intentio are that the next conference w be in Chicago during the first Oc tober following the end of trav restrictions but permitting the a rangement of a suitable progra

OCT. 2; SOCIETY FOR MEASUREMEN AND CONTROL (New Jersey), Ai Operated Control and Industri Application, by E. R. Huckman; Es sex House, Newark, N. J.; H. S Close, secretary, 831 Dixie Lan Plainfield, N. J.

OCT. 18-20; OPTICAL SOCIETY OF AMERICA, Thirtieth Annual Meeting; Hotel Pennsylvania, New York; N. Y.; Arthur C. Hardy, secretary, Massachusetts Institute of Technology, Cambridge 39, Mass.

WASHINGTON NEWS

NAVAL RESEARCH. Under direct supervision of Naval Secretary Forrestal, a new office of Research and Inventions has been formed to guide postwar Navy research activities. Electronic research is to be coordinated through the design branch of the electrical division of the bureau of ships and the equipment branch with research projects farmed out to colleges and universities on the basis of adaptability.

BROADCAST CONSTRUCTION. Amendment of Limitation Order L-41 allows without special WPB permission broadcast construction jobs in amounts not exceeding $1000. A previous $200 ceiling existed.

X-RAY EQUIPMENT. Restrictions have been lifted from the shipment of X-ray equipment for civilian purposes by revocation of Limitation Order L-206. Affected equipment includes power units; radiographic, fluoroscopic, and therapy tables; photo-fluorographic units; cassette changers; and tube stands. Because production of most items

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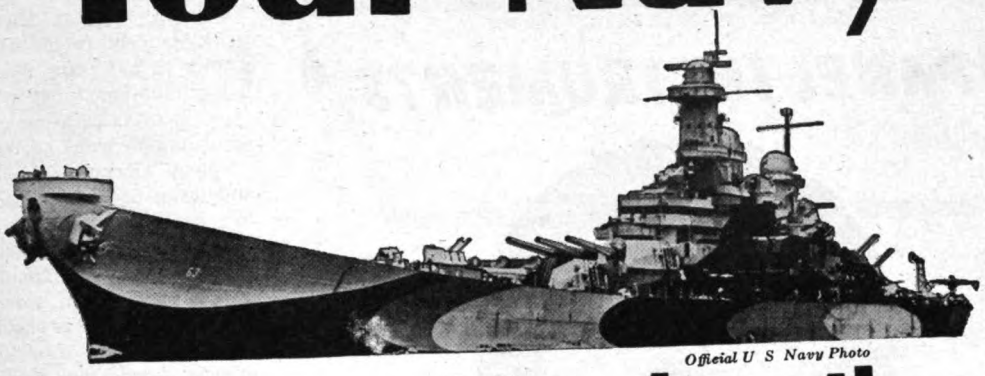
Your Navy



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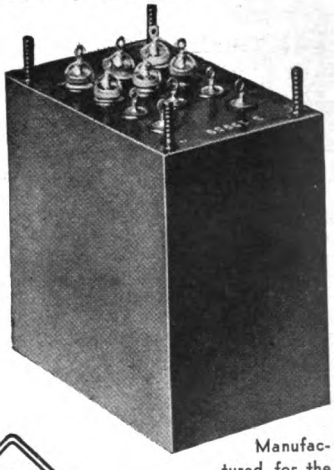
accepts nothing less than Perfection

That's why **KENYON HERMETICALLY SEALED TRANSFORMERS AND REACTORS** have been selected to play their part in the great forward march of the world's greatest Navy which demands and accepts nothing less than perfection of all its personnel and resources.



Manufactured for the Navy to their specifications RE 13A 553 B

The construction employed in the unit illustrated will meet present government specifications from any branch of the armed services. **KENYON'S** high standard of quality has been diligently maintained to insure a product of perfection.

Designs available employ both glass-to-metal and steatite-to-metal sealed terminals.

Overall dimensions and mounting dimensions conform to the **KENYON** T-line case except that the mounting is single ended at top or bottom. It may be necessary to increase case height.

THE MARK OF EXCELLENCE

Inquiries invited. Write for our new 1945 illustrated catalogue

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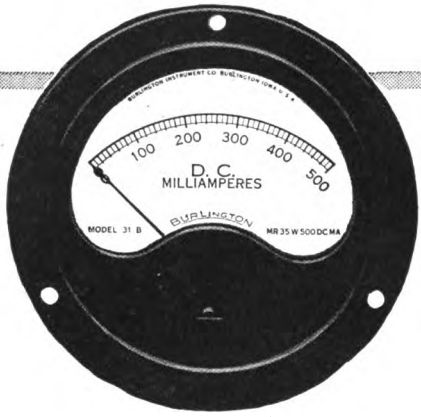
Burlington

PANEL INSTRUMENTS



Guaranteed ACCURACY

Due to design characteristics and close control of manufacturing processes, Burlington instruments embody the following advantages:

PERMANENCE OF CALIBRATION . . . All DC instruments employ Alnico magnets which are known to be more highly resistant to shock, heat, vibration, and stray fields than any other magnetic material.

FREEDOM FROM STICKING . . . Clearances for all moving parts are such that the results of entrance of small particles as encountered in field service are reduced to a minimum.

STABILITY OF OPERATION . . . All instruments are "NORMALIZED" after assembly to eliminate "zero shift" and other calibration errors due to ageing.

Exceptionally high torque to weight ratio of control springs to moving element insures minimum error under conditions of shock, vibration, and other rough usage.

Alignment of jewels and magnet core piece is such that the center lines of these parts coincide within plus or minus .002". The design of the brass movement frame and components is such that mechanical tolerances are reduced to a minimum in assembly. As a result, jewel and pivot wear is uniform which reduces "frictional torque" of the moving coil.

All series resistors and coils are heat treated and impregnated after wrapping to insure stability and long life.

All ranges AC & DC are available in 2½", 3½" and 4½" sizes, both square and round, flush mounting.

Engineering service furnished for specialized applications. No obligation. Write today for further information.

BURLINGTON INSTRUMENT CO.
100 FOURTH STREET
BURLINGTON, IOWA

PANEL INSTRUMENTS • VOLTAGE REGULATORS • AUTOMATIC SYNCHRONIZERS • FREQUENCY REGULATORS

requires six to twelve months, this equipment will not become generally available before that length of time, but production planning can be more efficiently executed according to WPB.

BLOCK AND FILM MICA. Paperwork incident to the use of most grades of block and film mica are being eliminated but without the removal of fabricating restrictions according to plans of WPB. Government stockpiles of high-grade and large-size mica must continue to be reserved for military demands, but it is pointed out that mica is available from domestic mines and certain foreign countries, and that users should explore the possibilities of obtaining the mineral from these sources rather than from government stocks.

INDUSTRY RECONVERSION. Appointments by the Committee on Period One (CPO) have been made to establish reconversion chairmen to facilitate the changeover from military to civilian production. In the communications division, the reconversion officer is Maynard A. Cook, whose responsibility will cover telephone and telegraph equipment, non-electronic military communication equipment, and radio headsets. In the radio and radar division, M. E. Karns is the reconversion officer covering vacuum tube machinery, transformers, capacitors, cable, microphones, loudspeakers, resistors, tube sockets, vibrators, test equipment, tubes, intercommunication equipment, instruments, sound systems, radio hardware, switches, repair parts, transmitters, receivers, and electronic heating generators. Control valves, regulators and industrial and commercial instruments come in the province of E. A. Capelle.

FCC ACTS

To permit this station	To do this
WJJD Chicago, Ill.	Construct developmental station to investigate multiplex f-m operation A0, A4, and special emissions (f-m); and 3-kw power.
Dayton, Ohio	Construct developmental station for f-m research; A0, A3, and special emission (f-m); and 1-kw power.
W9XEK Louisville, Ky.	Increase power to 10 kw; add A4 emission; change frequency from 45.5 Mc to assigned frequencies and change transmitter.
W8XFM Cincinnati, Ohio	Change classification from temporary class-2 experimental high-

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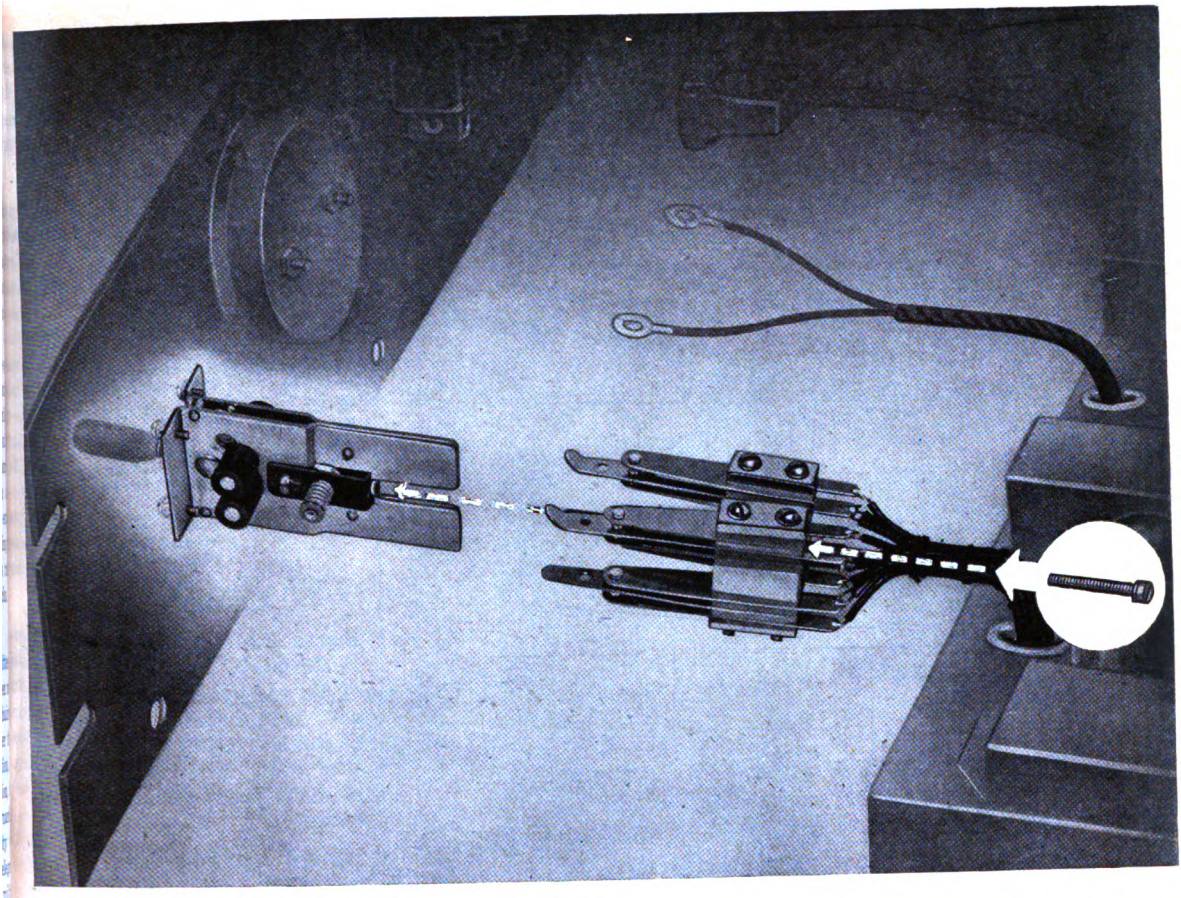


Single Bolt Assembly ON MODEL MCL LEVER SWITCHES

SPEEDS CHASSIS-TO-PANEL ASSEMBLY ON ELECTRONIC & COMMUNICATIONS EQUIPMENT

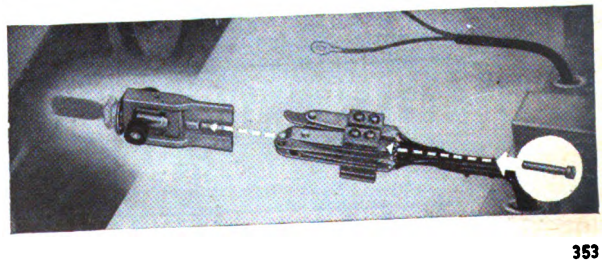
This *exclusive** General Control Company feature means savings in time and labor during original assembly and at any time that maintenance, rewiring, etc. is required. Consider the convenience of this feature when build-ups must be assembled to a frame that is buried among other units on the back of the control panel. During assembly of equipment, the Model MCL can be wired where it is most convenient—the control lever can be mounted anywhere on the panel where it is most convenient for the operator—there is no need to compromise.

The "Midget" Model MCM also has the single bolt assembly feature. This unusual lever switch *weighs only 3¼ ounces with 12 contact springs.*

All General Control Company lever switches have unlimited contact possibilities; all parts are non-corrosive; all have easy, positive roller action, regardless of number or arrangement of contacts on each side of switch.

* PATENT No. 2,351,236

The "Midget" MODEL MCM *has it too!!*



GENERAL CONTROL COMPANY

1202 Soldiers Field Road **BOSTON 34, MASS.**

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ELECTRONIC AC VOLTMETER

with Logarithmic Scale

Percentage Accuracy of reading is uniform over entire scale!

MODEL 300
ELECTRONIC
VOLTMETER

ACCESSORIES

MODEL 220 DECADE AMPLIFIER
MODEL 402 MULTIPLIER

Since its development in 1935 the Ballantine Electronic AC Voltmeter is the only instrument of its kind with a Simplified Logarithmic Scale.

The important feature of logarithmic scale indication in the Ballantine Voltmeter provides the same degree of accuracy at 1 as at 10. Also the simplicity of this scale reduces errors in visual observation, common with most multi-range instruments. Finally, the care taken in overall calibration combined with the inherent stability of the circuits used permits reliable readings within the 2% specified tolerance over the complete range of operation.

Write for descriptive technical Bulletin 8

BALLANTINE LABORATORIES, INC

BOONTON, NEW JERSEY, U. S. A.

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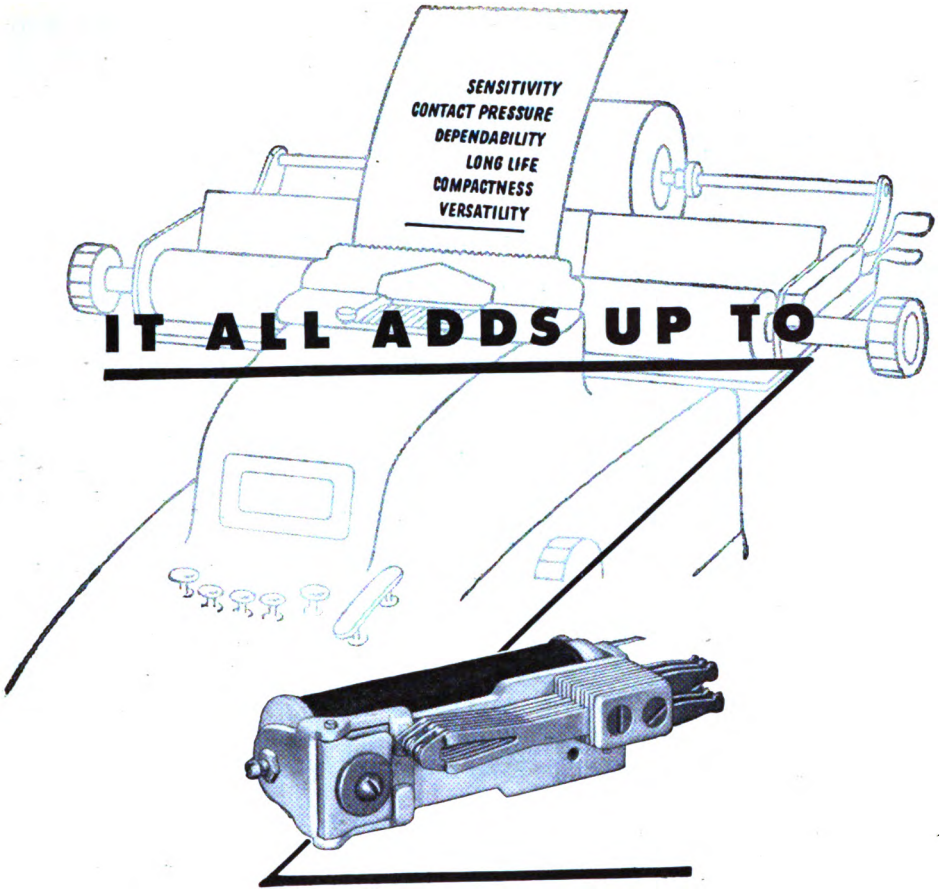

AUTOMATIC ELECTRIC'S CLASS "B" RELAY

All six of the features you want—perfectly combined in one unit—that's what you get in this new relay. It meets all purposes, in widely varied applications, without compromising with the most exacting requirements. For in the Class "B" relay, Automatic Electric has combined the features you need—*all* of them, and each in greatest measure.

Independent twin contacts for dependable contact closure... efficient magnetic circuit for sensitivity and high contact pressure . . . unique armature bearing for long wear under severe conditions . . . compact design for important savings in space and weight. Now available for coil voltages to 300 volts DC and 230 volts AC, with capacities up to 28 springs; also with magnetic shielding cover, when specified.

The Class "B" relay, and many others, are shown in Catalog 4071. Write today for your copy.

Relays by **AUTOMATIC ELECTRIC**

AUTOMATIC ELECTRIC SALES CORPORATION
1033 WEST VAN BUREN STREET • CHICAGO 7, ILLINOIS
In Canada: AUTOMATIC ELECTRIC (CANADA LIMITED, TORONTO

PARTS AND ASSEMBLIES FOR EVERY ELECTRICAL CONTROL NEED

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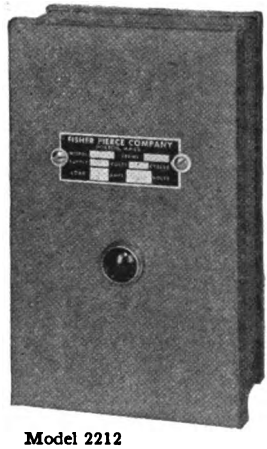
FISHER-PIERCE
Electronic Relays

SAVE CONTACT WEAR



Model 2212

● A controlling current of .000006 amperes provides operation of a 2 ampere load on 115 volts 60 cycles.

● A supply circuit (115 volts 60 cycles) furnishes only 3 watts of stand-by power. No power is required from the controlling circuit — only the closure of a loop to permit the passage of 6 microamperes from an internal 6 volt source. A built-in transformer isolates this controlling circuit from line and ground.

● Load contacts are S.P.D.T. with pilot lamp for 115 volts on the N.O. contact, showing action of the relay even when the cover is closed. Load relay is of the plug-in type, permitting easy change when unusual loads require special load contacts. Conservative design insures extremely long tube life.

● Rugged steel box with hinged cover is fitted with a hanger and equipped with adequate knock-outs.

Interior View

Send us your control problem and ask for Bulletin 4510

FISHER-PIERCE
COMPANY
62 CEYLON ST., BOSTON 21, MASS.

increased export business; and in the Echophone line of products including commercial and citizens radio communication equipment.

GOTHARD MFG. CO., Springfield, Ill., is building a modern daylight plant including engineering and research as well as manufacturing facilities for pilot light assemblies.

WOODWARD AND KEEL, Washington, D. C., has been dissolved as a consulting engineering firm. Practice will be continued under the name of John J. Keel at 648 Earle Building, Washington 4, D. C.

SOLAR MFG. CORP., New York, N. Y., purchases a modern factory building at North Bergen, N. J. It is designated as Plant Number 4 and postwar it will become the company's main eastern plant. The company, more than two-thirds of whose prewar production went into radio receiving and transmitting apparatus, expects the postwar ratio to drop to approximately 50 percent radio components with the other 50 percent going into business machines, safety devices, hearing aids, and similar products.

ALLEN B. DUMONT LABORATORIES, Passaic, N. J., have the assignment of a patent by Dr. Thomas T. Goldsmith, covering a system where incoming negative television signals are photographed on positive film by motion picture camera for immediate subsequent projection in theatres.

RAYTHEON MFG.. CO., Waltham, Mass. is planning the erection of a television and f-m broadcasting station in Prospect Hill Park, one of the highest points in metropolitan Boston.

CANADIAN MARCONI CO., Montreal, Canada, is supplying a new three-way police radio system to the town of Montreal West. Operating on f-m, the system permits two-way communication between headquarters and cruiser cars and between cars.

SELENIUM CORP. OF AMERICA, Los Angeles, Calif., is the newest member of the Los Angeles Council, West Coast Electronics Manufacturers' Association.

GRENBY MFG. CO., Plainville, Conn. and Allen D. Cardwell Mfg. Corp. Brooklyn, N. Y., consolidate. In-

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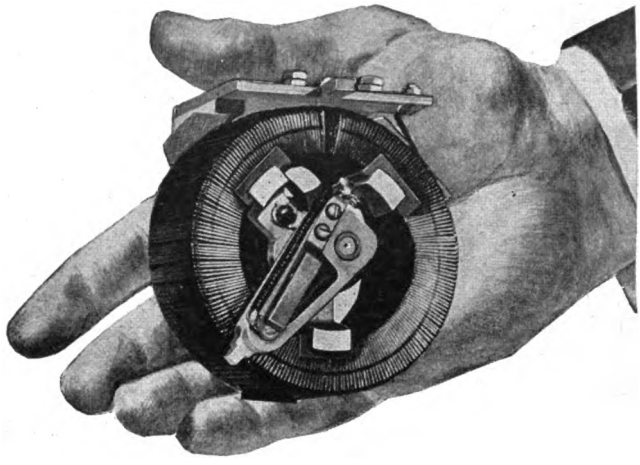
is this What You Want?

But Fast



SORENSEN CAN MEET YOUR DELIVERY DATE ON LIGHT WEIGHT 350-2400 CYCLE VARIABLE VOLTAGE CONTROLS.

How fast do you need them? Sorensen & Company takes pride in their record of meeting or beating delivery dates. You name the date — we'll start shipping.

The single phase 500 V A Variable Voltage Auto Transformer is designed for an input of 115 volts; output 0–130 volts, 350–2400 cycle, maximum 3.85 amperes, rated 3 amperes. Continuous duty, single phase without air blast cool. With 50 C.F.M. air blast with an ambient of plus 50 degrees centigrade the single phase unit is capable of 1.2 K.V.A. Weight of the single phase unit is 1.85 lbs.

The three phase 1.5 K.V.A. Variable Voltage Auto Transformer is designed for an input of 208 volts "Y" connected; output 0–235 volts, 350–2400 cycle maximum 3.85 amperes. Continuous duty, three phase, without air blast cool.

With 100 C.F.M. air blast with an ambient of plus 50 degrees centigrade the three phase unit is capable of 3.5 K.V.A. Weight of the three phase unit is 5.4 lbs.

The single phase 1.5 K.V.A. Variable Voltage Auto Transformer is designed for an input of 115 volts; output 0–130 volts, 350–2400 cycle maximum 11.5 amperes, rated 9 amperes. Continuous duty, single phase, without air blast cool.

With 100 C.F.M. air blast with an ambient of plus 50 degrees centigrade the single phase unit is capable of 4.5 K.V.A. Weight of the single phase unit is 3.85 lbs.

The three phase 4.5 K.V.A. Variable Voltage Auto Transformer is designed for an input of 208 volts "Y" connected; output 0–235 volts, 350–2400 cycles maximum 11.5 amperes, rated 9 amperes. Continuous duty, three phase, without air blast cool. With 150 C.F.M. air blast with an ambient of plus 50 degrees centigrade the three phase unit is capable of 10 K.V.A. Weight of the three phase unit is 8.9 lbs.

All of the above units were designed for air-borne equipment. They are built with class "B" insulation, a new commutator forming process is employed that eliminates the necessity of reducing copper area on the commutator face.

SORENSEN & COMPANY

AIRBORNE ELECTRONICS • • • **STAMFORD, CONN.**

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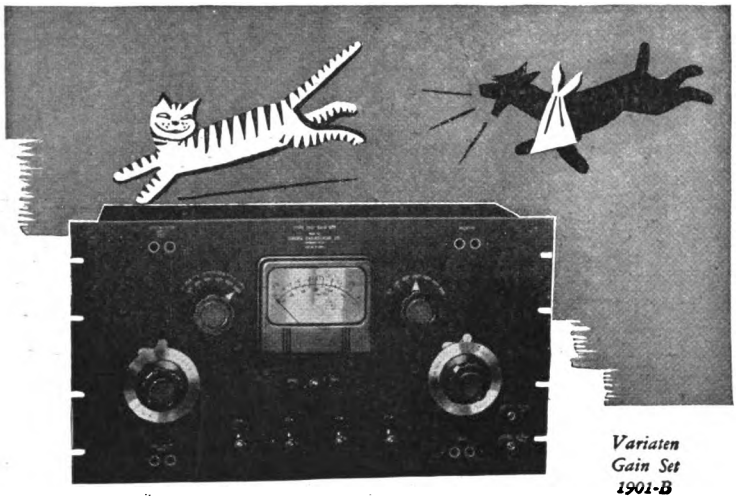

Variaten Gain Set 1901-B

As necessary to perfect Amplifier performance as the fourth leg to a dog!

You can't have perfect performance in amplifying or other speech transmission without knowing the efficiency and performance of each unit in the installation.

With a Variaten Gain Set you can (1) measure the total amplification of an amplifier; (2) measure the gain at all frequencies to determine whether there is discrimination against any part of the frequency spectrum; (3) measure the power output of any amplifier; (4) measure frequency response of transmission lines in absolute quantities; (5) check all control equipment—in fact, quickly make a quantitative analysis of any part of the audio frequency spectrum.

Unvarying accuracy is all-important. Variaten Gain Set, Type 1901-B (shown above) has a flat frequency characteristic of 0 to 20 kilocycles, and leakage is *guaranteed to be less than 1/10th db.* (Measurements have been made at frequencies as high as 100 kilocycles with practically no error.)

Variaten Gain Set 1901-B is equipped with both send and receive impedance matching controls for *both* Straight T and Balanced H circuits. This dependably accurate instrument can be supplied with either one or two meters.

Write today for complete data on Type 1901-B and other Variaten Gain Sets.

Other Variaten products—*Attenuators, Mixers, Resistors, Matching Pads and other precision sound equipment meet the most exacting specifications. Catalog on request.*

VARIATEN

CINEMA ENGINEERING CO.

Established 1935 • Burbank • California

dividual corporate identity and present management will be continued, bringing together complementary engineering, research and manufacturing facilities in both the electronic and mechanical fields.

WIRE RECORDER DEVELOPMENT CORP. is the name of a newly organized offshoot of Armour Research Foundation of Illinois Institute of Technology. The new corporation will take over all commercial functions related to manufacture of wire recorders.

STANDARD ELECTRICAL PRODUCTS CO., Dayton, Ohio, is again engaged in manufacture of transformers, control devices, and relays for airborne radio and radar operation. Full production is expected to commence in a short period.

AIR-TRACK MFG. CORP. is sold by the parent company, F. L. Jacobs Co., Detroit, Mich., to Robert I. Sarbacher and Robert H. Bailey. Manufacture of electronic gear will continue.

PERSONNEL

ALBERT S. EISENSTEIN gets one of five Frank B. Jewett fellowships for research in physical sciences for the year 1945. Dr. Eisenstein, who is at present a member of the Radiation Laboratory staff at Cambridge, receives a stipend of $3,000 while a further honorarium goes to the institution where his research is done.

GEORGE L. BEERS is appointed assistant director of engineering in charge of advance development in

the RCA Victor Division of Radio Corp. of America. He was previously on the engineering administrative staff.

GEORGE MILNE is appointed director

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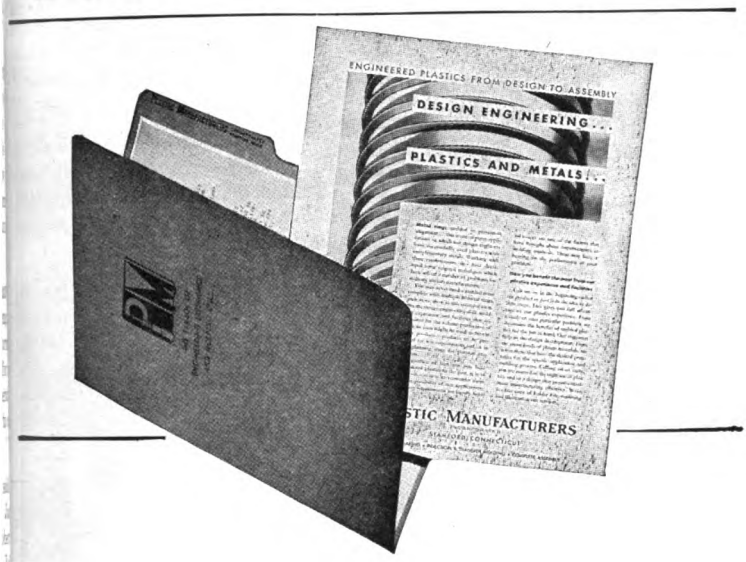
PLASTICS INFORMATION

YOURS...IN THIS CONVENIENT FILE FOLDER

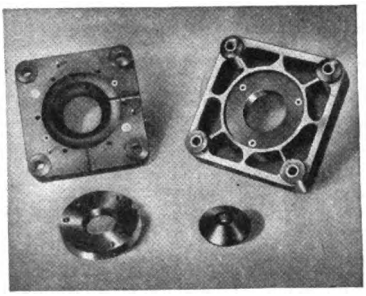


Our handy-reference Folder is designed to be a useful part of your plastics source file. It contains information on the facilities of our organization for plastics engineering, designing, molding and assembly, and includes examples of plastics applications that may have a relationship to your peacetime products. The Folder is free, on request.

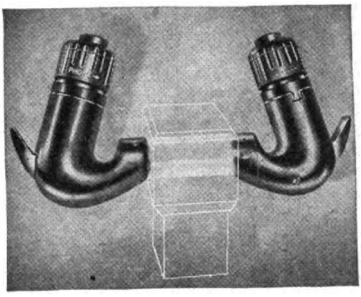
Plastics should be reappraised now in the light of improved methods and materials that have been tested in extensive wartime applications. To help you in your consideration of plastics, send for our Folder File. And call on us early in the design stage of your products. This assures the fullest benefit from our molding experience, and the most practical advantages from plastics.

PM REG. U.S. PAT. OFF.

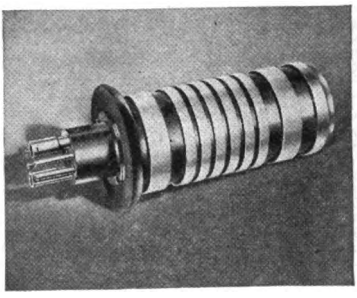
Write now for Folder File E8



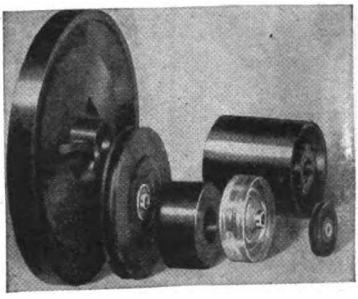
PRECISION MOLDED PARTS



PLASTIC CONTROL GRIPS



PLASTICS AND METALS COMBINED



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- TERMINAL STRIP ASSEMBLIES
- ANTENNAE
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- SPECIAL EQUIPMENT
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For Complete Details

Write for Catalog

KINGS ELECTRONICS CO.

372 CLASSON AVE.

BROOKLYN 5, N. Y.

of technical operations for the Blue Network of American Broadcasting Co. He was formerly chief engineer.

E. W. D'ARCY goes to the post of chief engineer at DeVry Corp. He was previously research engineer at Essanay Film Corp. and has been with DeVry in a similar capacity since 1940.

C. B. JOLLIFFE, chief engineer of RCA Victor Division, Radio Corp. of America, becomes vice president

in charge of RCA Laboratories. He succeeds to this post Otto S. Schairer who becomes consultant and advisor.

FRANK MARX, former head of the technical advisory group in the Blue Network of American Broadcasting Co. becomes director of general engineering.

N. F. SHOFSTALL is appointed designing engineer of the receiver division in the General Electric Company's electronics department.

He has been serving as chief broadcast receiver engineer, responsible for technical designs of domestic and export broadcast receivers.

J. Z. MILLAR, Colonel, U. S. Army Signal Corps, is appointed radio research engineer for Western Union Telegraph Co., New York, N. Y. He was previously in the electronics division of the same company.

SCOTT HELT is made supervising

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FOR SPEEDY ASSEMBLY
ON THE PRODUCTION LINE—

FOR SPEEDY MAINTENANCE
IN THE FIELD

IT'S THE AMP SPLICING TERMINAL

ONLY 2 PARTS!
BOTH IDENTICAL

QUICK POSITIVE SPLICE, STAYS TOGETHER UNTIL INTENTIONALLY TAKEN APART

NO SOLDER!

USE THROUGHOUT IN THE MANUFACTURE OF WIRING SYSTEMS; HARNESSES, COMPONENTS, ETC.

ASSEMBLY LINE ECONOMY

The AMP Knife-Disconnect Splicing Terminal is easy to put into an assembly line, for no skill is required even by untrained workers to install AMP solderless terminals. (Many plants are already set up and are producing new equipment using these modern quick disconnect terminals, thereby eliminating retraining of workers to unfamiliar obsolete methods.)

THE AMP Splicing Terminal uses *identical* ends, perfectly engaged. Just crimp the AMP Splicing Terminal on the wire and it's ready to be attached to any other AMP Splicing Terminal or similarly designed AMP integral stamping. When the two identical ends are engaged, slip insulation sleeving over the joint and you've a connection giving maximum electrical and mechanical performance.

QUICK CONNECTION AND DISCONNECTION FOR MAINTENANCE

There is no need to remove equipment housings, unscrew binding posts, or cut wires to remove or repair equipment—merely place AMP Knife-Disconnect Splicing Terminals at the right spots for easy servicing. Then it is a simple matter to disconnect the wire or wires and lift out the part or work on a cold circuit. Here is maintenance lowered to its irreducible minimum.

Design quick disconnection into electrical equipment with the AMP Splicing Terminal. It works for you all the way down to the service man.

Write today for samples of AMP Splicing Terminals—wire sizes from 22 to 8 inclusive.

SEND FOR BULLETIN 31A

ONE SPLICE END TO THE WIRE

TERMINALS WITH OR WITHOUT INSULATION SUPPORT
PRE-INSULATION OR CORROSION PROOFING

THE OTHER A PART OF THE EQUIPMENT

THIS END MAY BE AN ADAPTOR PART OR AN INTEGRAL PART OF THE EQUIPMENT

AMP

AIRCRAFT-MARINE PRODUCTS INC.
1521-53 NORTH FOURTH ST., HARRISBURG, PENNA.

In Canada: David C. Orrock, 1405 Bishop St., Montreal, Quebec; F. N. Adams, 726 Homer St., Vancouver, British Columbia

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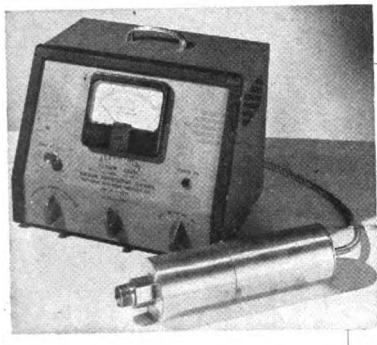
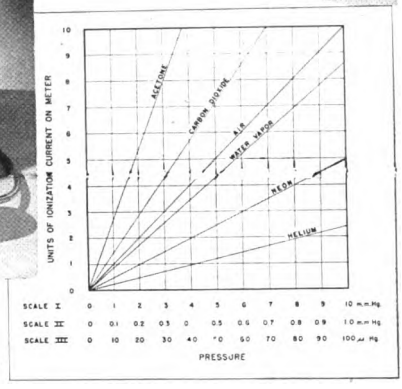
In Vacuum Gauges . . . its the new

Alphatron

No. 3 in series on new developments in the field of High Vacuum





Alphatron Gauge Type 510
Preliminary Calibration Scale

1 micron to 10 millimeters . A single gauge giving continuous linear indication of pressure in three ranges: 1–100 microns; 1–1000 microns and 1–10 millimeters.

instantaneous response . . The Alphatron utilizes the ionization effect of alpha particles. This new principle enables instantaneous response to pressure change and thus avoids lag in readings.

undamaged by atmospheric pressure . . . . . The flow of alpha particles is produced from a sealed radium source. There is no filament to burn out, and the gauge is unaffected by exposure to atmospheric pressure.

simple calibration for different gases . . . . The graph above shows that the Alphatron has linear reactions to pressure throughout its entire range. Calibrated for dry air the standard Alphatron may be used directly for other gases by means of calibration factors. Excellent for use with systems containing water vapor and for leak detecting.

specifications . . . . Control box: size 12⅝" x 9¼" x 9⅜", weight 20 lbs., finish grey and black crackle with red trim; gauge (including first **stage** amplifier); size, 12" x 3" O. D., weight 5 lbs., finish natural; cables: 10 feet special 10 conductor; power 110 volts, 60 cycle, A. C., 1 ampere; calibration as shipped: dry air; shipping weight; approximately 27 lbs.

Vacuum ENGINEERING DIVISION
NATIONAL RESEARCH CORPORATION
BOSTON 13, MASSACHUSETTS, U.S.A.
High Vacuum for Industry

For full particulars send for bulletin G-3.

engineer for Studio A at the Du Mont television station, WABD, New York, N. Y.

DR. LORENZO EMO, specialist in artificial radioactivity, joins the staff of Battelle Memorial Institute, Columbus, Ohio, where he will be engaged in research on industrial physics.

DON C. MCRAE returns to Eastern Air Lines as superintendent of communications. He has been serving with the Armed Forces since May, 1942.

PAUL DE MARS, still on active duty as lieutenant commander in the Navy, joins the consulting firm of

Raymond M. Wilmotte. He will ultimately be identified with a new department for industrial electronics within the firm.

DANIEL W. GELLERUP returns to the staff of the Milwaukee Journal Radio Stations, WTMJ and WMFM as broadcast technical supervisor. He has been on leave to the National Defense Research Council, Columbia University, assigned to the Bureau of Ships, U. S. Navy.

E. N. WENDELL, long-time member of the engineering staff at International Telephone & Telegraph Corp., New York, N. Y. takes charge of the radio division of Federal Telephone & Radio Corp. Among his former activities was the development of instrument landing systems for CAA.

JACK DAVIS becomes chief engineer of the auto radio division, Galvin Mfg. Corp., Chicago, Ill.

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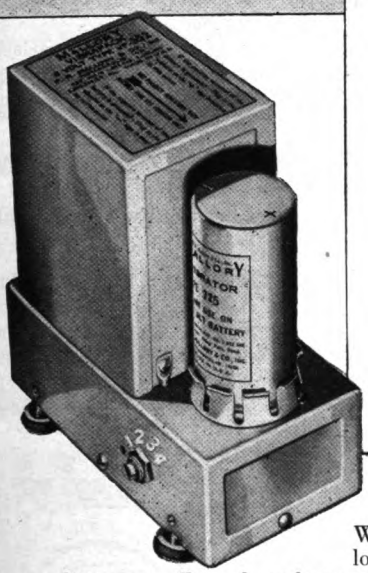
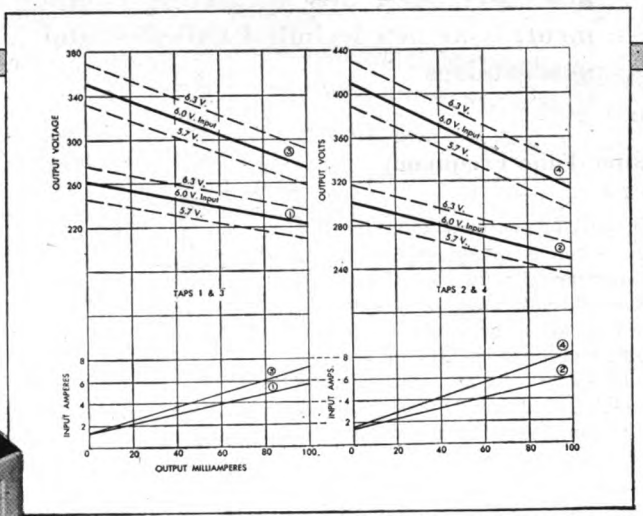
MALLORY VIBRAPACK*

Provides Dependable Plate Power for Portable Electronic Equipment





Operating characteristics of Mallory Vibrapack VP-552

Wherever dependable high voltage is required from a low voltage DC source, Vibrapacks* are built to deliver plate power efficiently and economically over a long life. Vibrapacks are used successfully in operating radio receivers, transmitters, PA systems, direction finders and other electronic apparatus on police cars, aircraft, automobiles, farms, boats, in military, naval, forestry and lighthouse service . . . wherever a source of commercial AC is not available.

Features of Mallory Standard Vibrapacks include:

Nominal input voltages of 6, 12 and 32 volts DC.

Nominal output voltages from 125 to 400.

Models available with switch for four output voltages in approximate 25-volt steps.

All *standard* Vibrapacks are equipped with new Mallory Hermetically-Sealed Vibrators for top performance in extremes of atmospheric pressure or humidity.

Heavy-duty Vibrapacks are available that will deliver up to 60 watts power. You can obtain Mallory Vibrators and Vibrapacks at your nearest Mallory Distributor. Ask him for literature, or write us today.

Inquiries are invited from manufacturers for Vibrators and Vibrapacks for use in original equipment.

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

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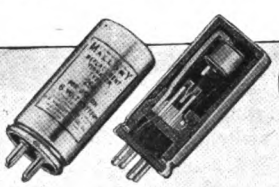
P.R. MALLORY & CO. Inc.

MALLORY



VIBRATORS and VIBRATOR POWER SUPPLIES

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NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

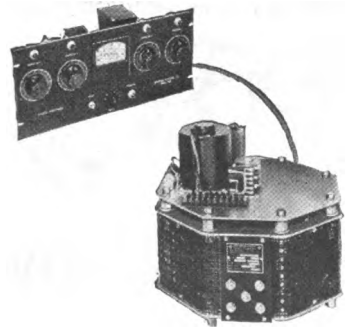
Vacuum Tube Frequency Meter

MODEL 39-VTF vacuum tube frequency meter is manufactured by J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn., and is designed to provide the maximum degree of accuracy in measuring frequencies located in the 400, 800, 1200, 1600, 2400 and 3600-cycle bands. A special multivibrator circuit in the unit divides the incoming frequency by 2, 3, 4, 6 and 9. The resulting frequency is measured by a standard vibrating reed frequency meter. Measurements in the above-mentioned bands are

rated 0.25 percent accuracy or better, independent of line voltage. This accuracy is maintained and no calibration or standardization is ever required. No initial stabilization period is required, and no protection is needed against accidental frequencies above the range being measured. Characteristics of Series A of this instrument are: Frequency ranges: Basic range 380-420 cycles. Multiplier switch permits use in ranges of 2, 3, 4, 6 and 9 times the fundamental range; input sensitivity 500,000 ohms; voltage range 100-350 volts; power consumption approximately 25 watts at 115 volts, 60 cycles; tubes used include 2-6N7 multivibrators, 1-6N7 input, 1-6J5 buffer, 1-6V6 amplifier, and 1-6X5 rectifier. The unit is housed in an 8 x 10 x 8 cabinet with a sloping panel.

Positioner

A SERVO-OPERATED variable voltage transformer, manufactured by Superior Electric Co., Bristol, Conn., was developed to fill the need for accurately controlling the plate power to a number of preset levels in dielectric heating apparatus. In this application it was desired to use an r-f generator to heat in sequence a number of mold preforms, each requiring a different power level. A control circuit is alternately connected to one of four controls which causes the output voltage of a motor-operated Powerstat variable transformer to increase from zero to a voltage indicated by the control dial. Connection to another control or resetting of the control in the circuit causes a corresponding change to take place in the Powerstat output voltage. The circuit is arranged so that this change of voltage is accomplished either by reducing to zero voltage and increasing to the new value or by continuous change to the new value without reducing to zero.

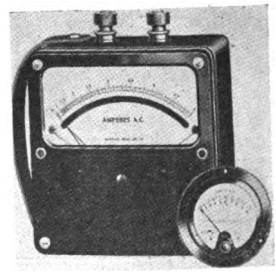


The apparatus consists of a motor-operated Powerstat variable transformer and remote positioning elements which are bridge connected. The output of this bridge is connected to a thyratron relay assembly which energizes the Powerstat driving motor until balance is reached.

Any Powerstat variable-voltage transformer from ½ to 100 kva may operate with this Seco remote positioner.

Frequency Compensated Instruments

WESTON ELECTRICAL Instrument Corp., of 617 Frelinghuysen Ave., Newark 5, N. J. announces that their a-c electrical measuring instruments can now be furnished with special forms of compensation



to maintain their accuracy over frequency ranges of from 25 to 3000 cycles. Instruments are furnished as ammeters, voltmeters and wattmeters in both the portable and switchboard types, flat compensated up to 1000, 2000 and 3000 cycles.

Crystal Unit

BLILEY ELECTRIC Co., Erie, Pa., announces a new low-frequency crystal unit (designated FM-6) that will maintain its frequency within narrow limits. The equipment utilizes a resonant pin assembly. The steel pins are mechanically resonant to the crystal frequency or some multiple of that frequency so that any damping effect of the clamping pins is negligible. The internal assembly is protected against moisture and humidity by means of

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Get Out From Behind 8 causes of wire-failure

1. High ambient temperatures
2. Aging and ozone oxidation
3. Moisture, alkalies, solvents
4. Conductor-heating overloads
5. High operating temperatures
6. Oil, grease, corrosive fumes
7. Arc fires and external flame
8. Cracking caused by vibration

One of the easiest low-cost methods of keeping 'on the ball' in the race for product acceptance is to give a little *extra* consideration to the selection of the *correct* wire for your particular application. Don't pick it by size, rating, appearance and price—insist on *lasting performance* under any and all conditions and you'll build a reputation for dependability that will bring increased sales.

A little wire can make your product look pretty bad if it fails to stand up in service, and savings of a few cents or dollars won't mean much if your customers aren't satisfied. A few avoidable trouble-starters are mentioned above—others not to be overlooked are excess voltage drop, inadequate current carrying capacity, and the burrs and tight bends that may abrade the insulation during installation.

Let us help you protect your product's performance with *permanently insulated* wires, cables and cords resistant to heat, flame, moisture, oil, grease, corrosive fumes or alkalies. 125 different constructions to select from—and Rockbestos Research will gladly work up a "special" to meet your *specific* requirements if a standard won't do. For engineering assistance and samples, write the nearest district office or:

ROCKBESTOS PRODUCTS CORPORATION
426 NICOLL STREET, NEW HAVEN 4, CONN.

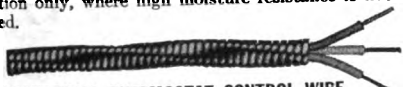
A Few Typical Rockbestos Constructions that assure long-lasting, dependable Performance:

ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

The first lightweight, small diameter, flame-resistant hookup wire designed in 1937 and widely used since in airborne and ground communications systems, electronic devices, instruments and apparatus. Operating temperature ranges from 125° C. to minus 50° C. Also with tinned copper shielding braid and in twisted pair or tripled construction. Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14, 16 AWG in 3000 volt.

ROCKBESTOS TYPE CA LEAD WIRE

Has high dielectric strength and moisture resistance for use where heat and humidity are encountered. No. 20 to 8 AWG solid or stranded copper, monel or nickel conductors insulated with synthetic tape and various thicknesses of felted asbestos finished in black, white or colors for coding purposes. Also with All-Asbestos insulation only, where high moisture resistance is not required.



ROCKBESTOS THERMOSTAT CONTROL WIRE

A multi-conductor control wire for low voltage intercommunicating, signal and temperature control systems. Its life-time heatproof and fireproof insulation and rugged abrasion-resisting steel armor will give you trouble-proof circuits. Sizes No. 14, 16 and 18 AWG in two to six conductors with .0125", .025" or (for 115 volt service) .031" of felted asbestos insulation and steel armor.

ROCKBESTOS A.V.C. 600 VOLT MOTOR LEAD CABLE

(National Electrical Code, Type AVA—max. operating temp. 110° C.)
Heatproof, fireproof, greaseproof and oilproof, this cable will not dry out and crack, won't burn or carry flame, and will remain permanently flexible. For coil connections, motor and transformer leads where overloads, extreme heat and fire hazards are encountered. Sizes No. 18 AWG to 1,000,000 CM insulated with two walls of felted asbestos and a high-dielectric varnished cambric insert, with a heavy asbestos braid overall.

A few of the 125 different wires, cables, and cords designed for severe or unusual operating conditions by Rockbestos.

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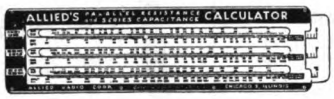
a captive gasket seal. The unit is designed for such applications as frequency standards, timers, measuring equipment, frequency meters, carrier current and other applications where an accurate source of low frequency is required.

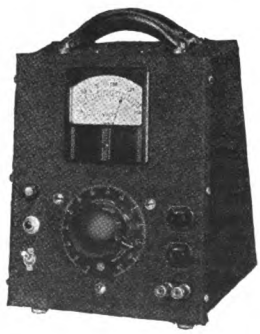
Calculator

ALLIED RADIO Corp., 833 W. Jackson Blvd., Chicago 7, Ill., has released a new parallel-resistance and series-capacitance calculator which is essentially a slide-rule device, designed to provide a rapid and accurate means of determining the reciprocal of the sum of two reciprocals as expressed by the formula $1/x = 1/a + 1/b$. A single setting of the slide automatically aligns all pairs of a and b values which will satisfy the equation for any given value of x. The calculator indicates the numerous pairs of resistors which may be connected in parallel, or capacitors in series to provide any required resistance or capacitance value. It is priced at 25 cents.



Voltage Control Unit

SUPERIOR ELECTRIC Co., Bristol, Conn. announces a new, compact and portable source of variable a-c voltage, designated as Voltbox. By simply connecting the unit to a single-phase outlet, an output variable from zero to above line voltage can be obtained. Accurate voltage



USE G-E

SAFETY SPARK GAPS

For Protection Against High-voltage Surges

G-E Safety Spark Gaps protect condensers against high voltage surges. These spark gaps are of the metal-to-glass sealed gas-filled type. They are calibrated on 60-cycle a-c peak.

Voltage spread between first trace of breakdown and complete breakdown is held to a minimum value for a wide range of rise times. Ratings are for ambient temperatures of 75° to 95° F. Breakdown voltage decreases with lower temperature and increases with higher temperature one to two volts per degree.

G-E Spark Gap ratings are 500-volts ±20 per cent, also 1200- and 2200-volts ±10 per cent.

Do you have an application for G-E Safety Spark Gaps? For additional information write to Section Q-856-119, Appliance and Merchandise Dept., General Electric Company, Bridgeport, Conn.

GENERAL ELECTRIC

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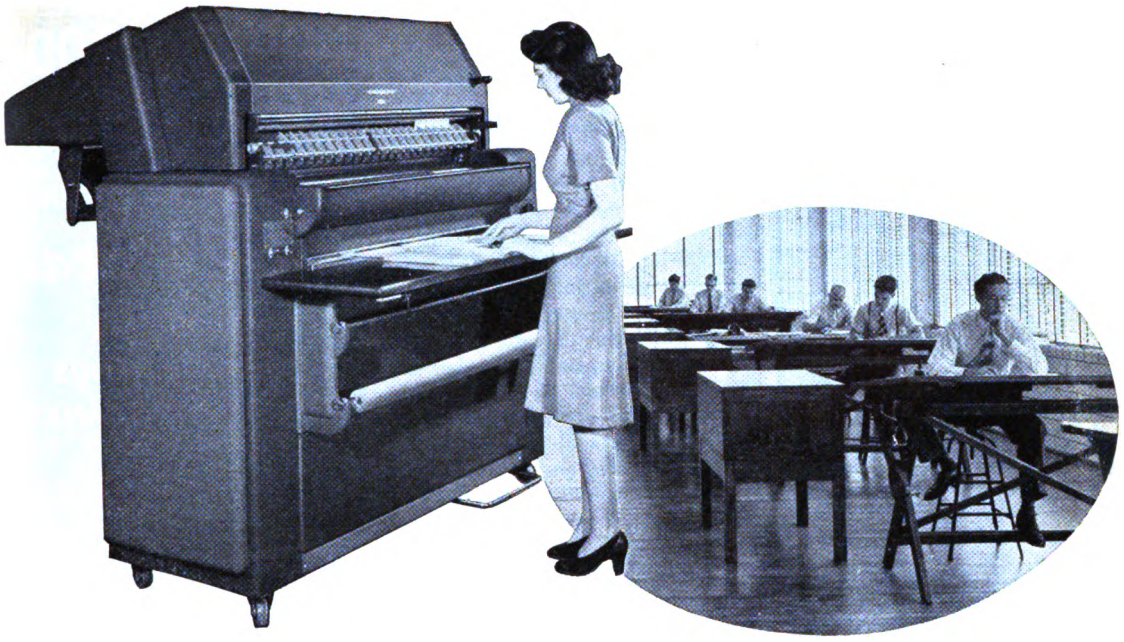

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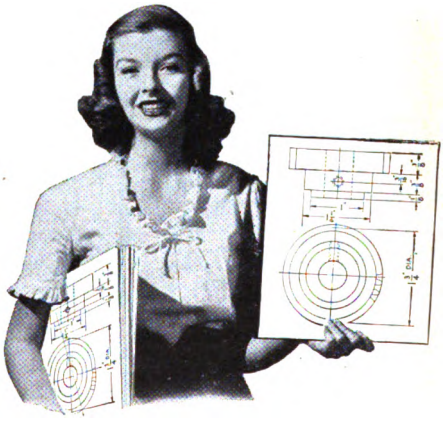

On the 75-159-B Volumatic Printer-Developer, BW Prints can be made on sheets cut to the exact size of your tracings to save trimming and waste, or from roll stock if you prefer. A BW machine is available also for large-volume roll stock production. The BW process is clean—noiseless—odorless. Even inexperienced persons quickly learn to make BW Prints.

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setting to 1 percent is assured by an easily read voltmeter displayed on the face of the Voltbox. Overloading is prevented by the use of a circuit breaker which also serves as an "on-off" switch. Model U-1000 (the letter U designates unregulated) operates from a 115-volt line to deliver an output variable from zero to 135 volts at 7.5 amp, while Model U-800 has twice the voltage rating and an output current of 3.0 amp. For line voltages which fluctuate to the extent that it is impossible to set and hold the voltage to a prescribed value, regulated Voltboxes (Type R-500) are available. This unit is similar to the unregulated types except that a voltage stabilizer is included in the unit. R-500 operates on 115-volt lines with a maximum output of 500 va.

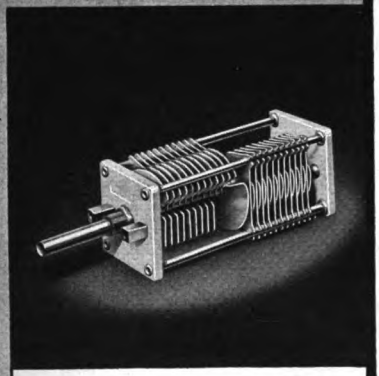
Universal Meter Scales

"HC" UNIVERSAL meter scales are used when converting 0-1 milliamp or more sensitive meters into multimeters reading a-c or d-c volts, ohms from one hundredth of an ohm to infinity and milliamperes in a sufficient number of ranges to satisfy any electrical measurement purpose. These scales are reproductions of individual precision calibrations and are made in four types for each of three different meters: Weston (Model 301), Jewell (Pattern 88) and Triplett (Model 321), making 12 different scales in all. They are reproduced on white and platinum Bristol board. Plain milliammeter scales, made only for Weston Model 301 meters, are available in the following ranges: 0-25, 0.50, 0-100 and 0.300 milliamp, dc. Each scale sells for 25 cents. R. E. Nebel Laboratory, 1104 Lincoln Place, Brooklyn, N. Y.

Thermoplastic Material

MONSANTO CHEMICAL Co., St. Louis 4, Mo., has begun volume production for the military of Styramic HT, a new thermoplastic which holds its shape and strength at relatively high temperatures (distortion point is 236 deg.) and which has high insulating qualities. The material is easily molded.

Designed for Application



The 28000-29000 Series Variable Air Capacitors

"Designed for Application," double bearings, steatite end plates, cadmium or silver plated brass plates. Single or double section .022" or .066" air gap. End plate size: 1 9/16" x 1 11/16". Rotor plate radius: ¾". Shaft lock, rear shaft extension, special mounting brackets, etc., to meet your requirements. The 28000 series has semi-circular rotor plate shape. The 29000 series has approximately straight frequency line rotor plate shape.

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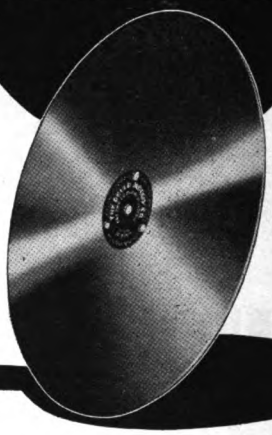

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FABRICATED PARTS used to insulate capacitors, loudspeakers, antenna systems and other radio components are now "in work" in Rogers' fabricating division. The radio industry has seen that it can advantageously use Rogers-Bord—and can have Rogers form, draw, punch, bend and shape these tough, high-dielectric materials. Rogers designs and produces the necessary dies in its own tool and die shop. The Rogers "you name it, we'll make it" slogan applies to special fabricating as well as to special fibrous and plastic materials. And it applies now.

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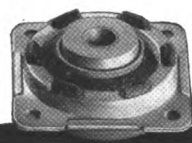
It is impossible for delicate instruments such as those used on planes, radios, or in the electronic field to take jars, jolts, shocks, and vibration and still maintain their accuracy or function efficiently for any length of time.

Harris Mounts cradle, cushion and protect instruments by absorbing up to 90 per cent of this "rough going" which is the death knell to sensitive precision made-instruments.

Harris mounts are rugged, yet, extremely light in weight. They are made in accordance with Army-Navy standards to suit any combination of weight, frequency, deflection, or operating condition and come in plate and cup form. Send in for free Bulletin Series 1022, giving complete data on Harris Mounts.

Our engineers, long experienced in the field of engineered vibration control, will gladly work on your problem with your engineers. Just drop us a line.



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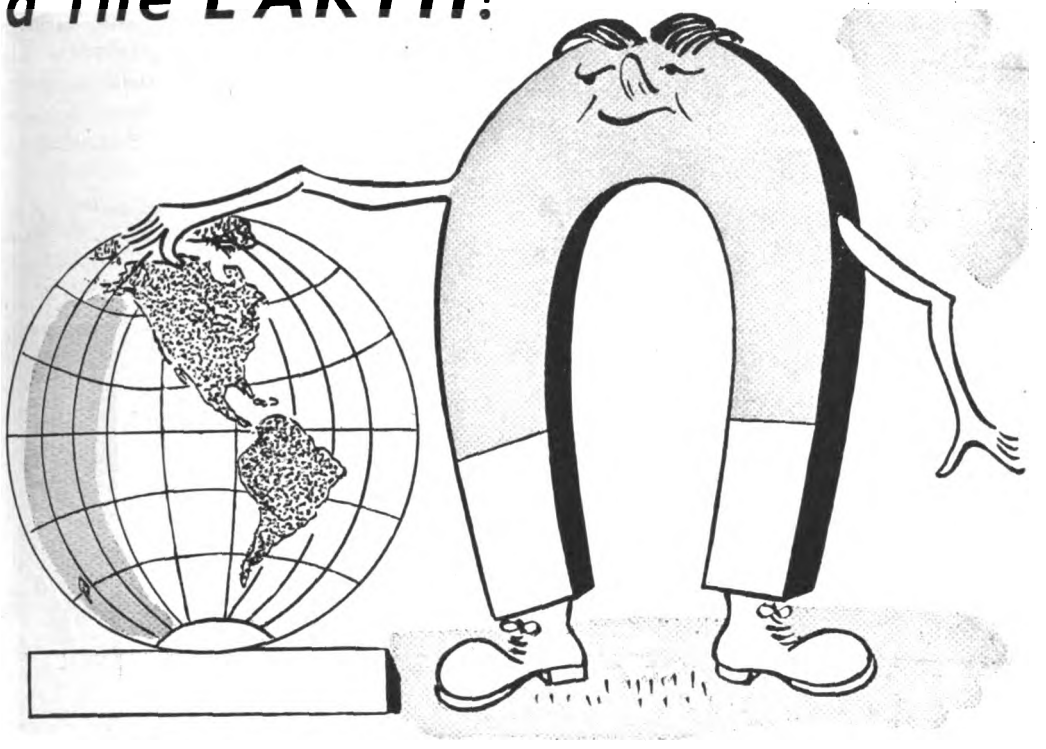
E and the EARTH!



• What do we have in common? What does the earth have that I can claim, too? It's a permanency of energy content that staggers the imagination! Although learned scientists have been arguing for years on the subject, "How old is the earth and how long will it last?", they all talk in figures that sound like the public debt. Whatever it is, it's a long, long time that the earth has existed and will last and, mysteriously, I'll last just as long. Unless abused or used as I shouldn't be, my energy content will never lessen no matter how long I am asked to provide a magnetic flux.

Permanency of energy content is a good reason for *all* designers of apparatus requiring a magnetic flux to make use of the *permanent magnet* . . . More about permanent magnets is given in our booklet, PERMANENT MAGNET DESIGN. Why not send for a copy?

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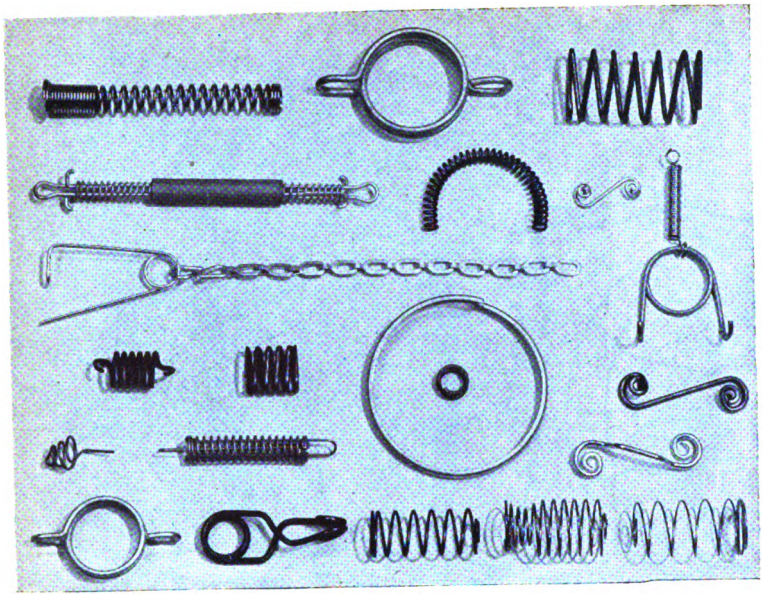

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Reliable

At the Reliable plant, our method of *scientific quality control* is based upon mathematically determined uniform frequencies of dimensional deviations. If this sounds complex, well, perhaps it is—but it's the system that safeguards Reliable Springs, so that fidelity to specifications, within given tolerances, actually approaches the absolute. Load factors, dimensions, squareness of ends, and other characteristics are rigidly controlled by statistical sampling. This painstaking inspection and testing process reduces to a safe formula the hazards to which all spring production is naturally subject. The final result is uniform, dependable spring performance.

Reliable makes all types of springs of round or square wire, or strip, as well as wire forms and light stampings. Reliable service to manufacturers is kept at a high level by an easily accessible and elastic organization of engineers and spring makers, always alert to your individual demands.

Advise us of your requirements. Catalog 44 sent on request.

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ROUND AND FLAT WIRE SPRINGS

CLIPS HOOKS BENDS LIGHT STAMPINGS

Lifeboat Radio

NEW LIFEBOAT RADIO equipment, complete with helium - filled balloon which supports the antenna, is shown here being demonstrated by cadet midshipmen of the U. S. Merchant Marine Academy. By releasing the balloon to the 300-foot limit of the antenna wire, the crew of an abandoned ship is able to

summon aid from a point 1000 miles or more distant. The equipment includes a self-contained power generator (which replaces storage batteries), and two-way radiotelegraph and radiotelephone facilities. The equipment automatically transmits SOS and radio direction finder signals. Radiomarine Corp., 75 Varick St., New York, N. Y.

Improved Converter Line

AMONG THE WAR application developments which have been adopted for all units are the new, special brass alloy slip rings with which Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill., has now equipped all units in its dc to ac converter line. Output of the units has been increased from 150-watt capacity to a 225-watt capacity.

Battery Receptacle

A NEW THREE-CONTACT battery receptacle conforming to Army-Navy Specifications AN2552 has been released by Cannon Electric Development Co., 3209 Humboldt St., Los Angeles, Calif. The fitting mates with any standard AN2551 plug, and is adaptable to aircraft starting equipment and other uses. Four combinations are available.

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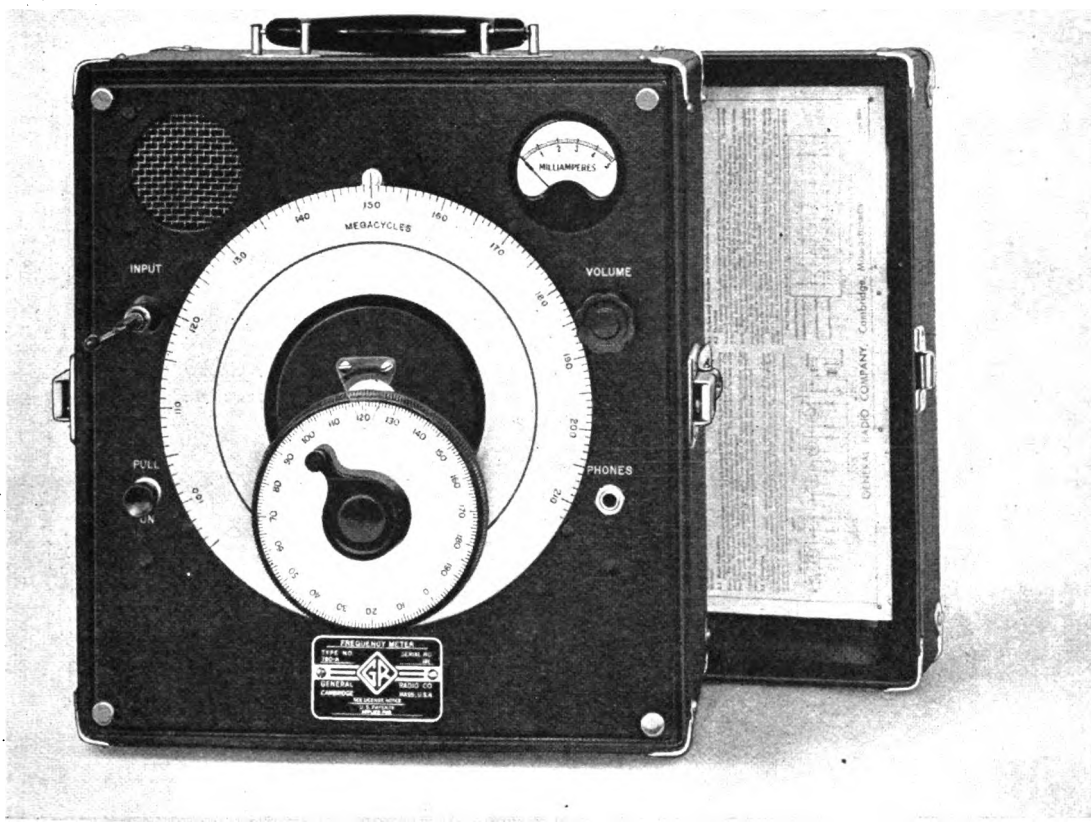

For Measuring Frequencies Between 30 and 3,000 Mc

The new G-R Type 720-A Heterodyne Frequency Meter has all the operating conveniences of a broadcast-band type instrument, with a range of 30 to 3,000 Mc. Heterodyne methods offer several advantages over the conventional resonant type of meter. The fundamental frequency can be low enough to insure stability difficult, or impossible, to obtain with the resonant-circuit instrument. The heterodyne meter has much greater sensitivity and consequently requires much less r-f power to operate.

The fundamental frequency of this new instrument is continuously variable between 100 and 200 Mc. Frequencies above and below this range are measured by the use of harmonics. The tuning element is a butterfly circuit with rotor ball-bearings and no sliding contacts. The fundamental range is direct-reading in megacycles with a dial scale-length of 15 inches. One division of the auxiliary dial corresponds to a frequency change of 100 parts per million.

The built-in detector is a silicon crystal Type 1N21B. Usually no auxiliary pick-up is needed except when frequencies above 1,000 Mc are being measured it may be necessary to adjust the input antenna which is mounted on the front panel.

A three-stage amplifier is provided to produce indication on the panel meter when strong signals are received. Audible beats are simultaneously heard in the small speaker mounted behind the panel. A jack is provided for plugging in headphones for weak beat notes.

The complete instrument is self-contained. Its price, with batteries and spare crystal is $250.00. At present this meter is available only for top-priority war orders. Reservation orders for future delivery, however, are being accepted.

For complete information see the G-R EXPERIMENTER for July, 1945.

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 1000 N. Seward St., Los Angeles 38

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You're Right!

YOU CAN'T GO WRONG

with KESTER FLUX

- Because Kester makes the RIGHT Flux for every kind of solder-bond. Delicate, dip-soldered electrical connections, sweating operations, various types of seams, all demand a different and correct flux if they are to be permanent, and resist shock, vibration, bending, contraction, and expansion without failure!
- Because for 46 years Kester has pioneered in the field of solder and flux. Kester engineers and technicians have laboratory-tested a vast range of fluxes for every possible requirement. You can't go wrong with Kester flux.
- Because you can consult Kester engineers at any time for practical, experienced help. They'll gladly suggest the right flux to protect your product. A letter today will bring expert Kester assistance—with no obligation.

★ BUY WAR BONDS ★

KESTER SOLDER COMPANY

4204 WRIGHTWOOD AVENUE, CHICAGO 39, ILL.

Eastern Plant: Newark, N.J. Canadian Plant: Brantford, Ont.

KESTER

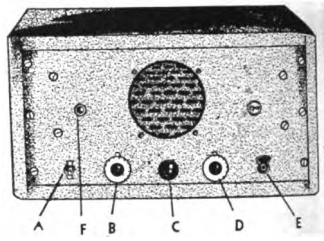
Solder Fluxes

STANDARD FOR INDUSTRY

Remote Tuner

MODEL NO. EP6 is a remote tuning attachment for practical remote control for communication receivers. The attachment gives the operator precise and perfect control once the receiver has been tuned to the approximate frequency.

Illustrated is the front view of control panel carrying a line amplifier, loudspeaker and voltage-regulated power supply for remote tuner operated from 110 volts, 60 cycle. Units for other voltages and frequencies are available on special order. The frequency of the remote



A—On-Off Switch
B—Band Spread Control and voltage regulated Power Switch
C—Tuning Control
D—Volume Control
E—Phono Jack
F—Pilot Light

receiver is adjusted by a tuning control (c) which varies the capacitance of a small capacitor connected across the oscillator capacitor of the receiver. The band spread control and voltage-regulated power supply (b) adjusts the width of the band covered by a 300-deg rotation of the tuning control. (A band width of 40 kc is considered sufficient to take care of frequency drift in either the receiver or the transmitter or to tune out other interfering stations if possible.) A standard two-wire telephone loop, not exceeding 3000 ohms, may be used to connect the remote control panel with the receiver tuning unit. One pair carries the remote control voltage and the audio signal. The amplifier is supplied with a 500-ohm input. Special equipment is available for longer lines. The on-off switch is designated by (a), (d) is the volume control, (e) the phono jack, and (f) the pilot light.

A 4-page bulletin from Electronic Products Co., Ltd., 673 Homer St., Vancouver, B. C. describes this unit and contains data on Model EP-4 tuner.

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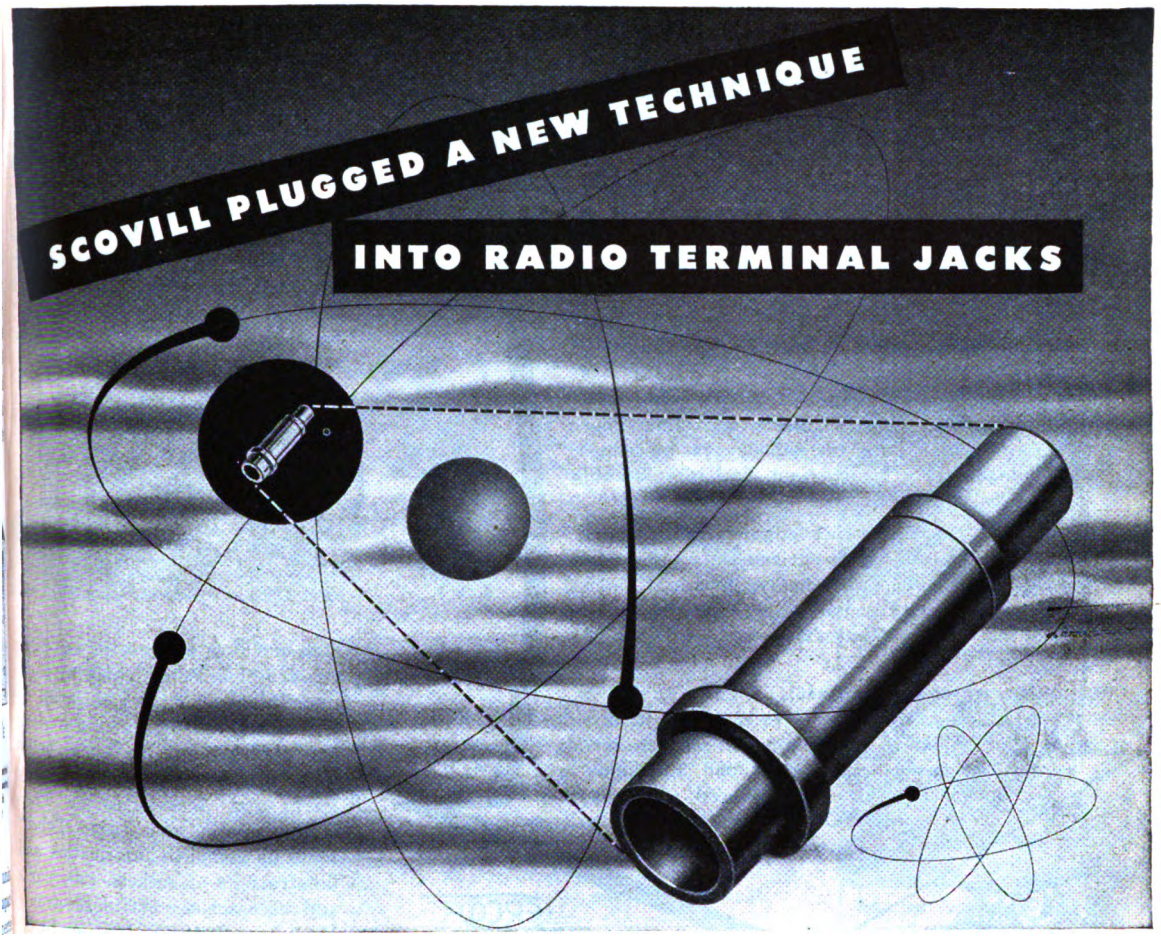

. . . and disconnected a tie-up

Terminal jacks for war-needed radios — screw-machined from rod stock —were lagging behind other parts. Expediters called on Scovill to break the bottleneck.

Scovill did just that by shifting to high-speed stamping of sheet metal. This change in technique stepped up production greatly . . . cut down on scrap, always a problem in screw machine operations . . . turned out eminently satisfactory work . . . lowered costs by a substantial margin.

Scovill Electrōnents* may also save time and money for you

Maybe your small electronic components or large assemblies can benefit from Scovill's versatility in forging, drawing, stamping, heading, or machining all kinds of metals and Scovill's impartiality in choosing the one method that will make your Electrōnents* faster and better for less. For further details of Scovill's designing service and manufacturing ability, send for literature. Use the coupon below and mail it today.

*Electrōnents = Electronic Components

Scovill
MANUFACTURING COMPANY
WATERBURY 91, CONN.

Please send me a free copy of *"Masters of Metal"* booklet describing your facilities. I am interested in the ELECTRŌNENT* applications checked.

☐ Batteries ☐ Dials ☐ Panels
☐ Record Changers ☐ Escutcheons ☐ Sockets
☐ Clips ☐ Jacks ☐ Stampings (misc.)
☐ Condensers ☐ Lugs ☐ Tubes

Other applications .....

SCOVILL MANUFACTURING COMPANY
Electronic Division
22 Mill Street, Waterbury 91, Connecticut

Name .....
Company .....
Address .....

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A COMPLETE RADIO STATION
all in one package!

Typical of ERCO'S engineering ability to build completely coordinated Radio Stations is the unit illustrated. Built for Sperry Gyroscope Company, Inc., this equipment unifies a 200-watt radio telephone and telegraph transmitter, three 32-D fixed frequency receivers, one variable frequency receiver, speaker panels and operating position.

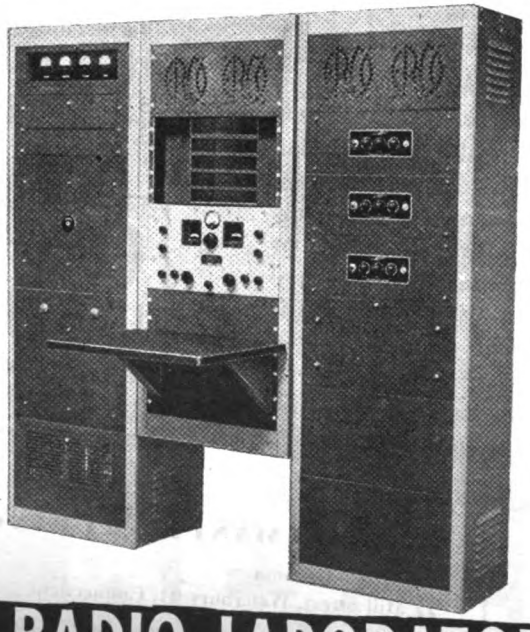
Variations of the illustrated console, in any combination of equipment, are available for your own needs. Panel assemblies can be interchanged to any arrangement. Each is replaceable to eliminate obsolescence.

ERCO'S specialized knowledge and technique is reflected in custom-built equipment for such varied users as Pan American Airways, American Airlines, General Motors, Eastman-Kodak, Grumman, Sperry, National Carbon, Westinghouse, and the Hudson's Bay Company.

Whatever your requirements . . . police, airline or industrial; mobile, ground to air, base to branch, office to field . . . ERCO provides complete service in the design, manufacture and installation of equipment that is engineered specifically to meet YOUR needs. We invite your inquiry.

ARMY E NAVY

ERCO



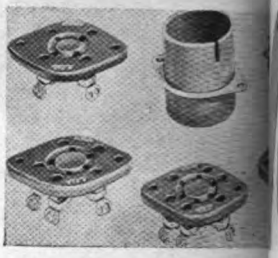
ERCO RADIO LABORATORIES INC

HEMPSTEAD, NEW YORK

Manufacturers of CUSTOM BUILT RADIO APPARATUS

Tube Sockets

A NEW SERIES of transmi... receiving tube sockets ... Mykroy (a mica ceramic ... ation which will not car... otherwise deteriorate in ... or electric arcs and flash... clude standard 4, 5, 6 and ... types, octal and loctal s... and 7 prong acorn sockets ... high-voltage rectifier soc... improved heavy-duty "50 ... Sockets are produced by ...



sion molding and are of ... construction featuring spr... phor bronze contacts an... the sockets so that they ... and non-turning. An 8-p... tin (No. 104) entitled ... Parts and Accessories ... tronic, Radio and Radar ... contains complete informa... illustrations of sockets, t... and accessories. Write E... Mechanics, Inc., 70-88 Clift... Clifton, N. J.

Resistors

AN IMPROVED LINE of non-i... resistors includes Types RI... manufactured by Instrume... tors Co., 25 Amity St., Litt... N. J. Type RL is rated ½ w... a maximum resistance of ... ohms. It measures ⅛ x ½ i...

SL has a maximum resistan... megohm and measures ⅛ x... Both resistors are furnished ... standard tolerance of ½ per...

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Fiberglas* Tying Cord puts the finishing touch on a quality Job

Fiberglas Tying Cords, ranging in size from 1/64" to ⅛", are an important part of the complete line of Fiberglas Electrical Insulation Materials. They are being widely used for all types of tying purposes on electrical equipment, or where high strength tension member is required.

Universally adaptable Fiberglas Cords provide all of the advantages inherent in Fiberglas, such as: heat, moisture, acid resistance, and exceptionally high tensile strength-to-size ratio. For example, the minimum breaking strength of 1/32" Fiberglas Cord, number EC5-1, is 66 lbs., that of ⅛" cord, number EC5-8-T, is 274 lbs.

Does many Jobs . . . Better

Fiberglas Tying Cords are widely used for banding field coils; for wrapping string bands on small armatures; for protecting front of the commutator V-ring from flashovers on motors; as banding, on the V-ring extensions on some d-c equipment; as filling, in winding certain coils; for reset strings; and for tying slot insulation in place. It is also used to lash ends of coils in large motors and generators, and to hold spacer blocks in place.

In general, Fiberglas Cords are from three to five times as strong as ordinary electrical twines. Therefore, Fiberglas Cords, smaller in size than cords of other materials, can be used for many applications.

Treated or Untreated

Treated cord is used primarily for its increased knot strength and abrasion resistance. For general applications in the construction or repair of electrical equipment, the treated cord is preferred. Where space is to be filled, regardless of strength requirements, the untreated cord is frequently used.

Complete Information

The new Fiberglas catalog EL44-7 gives performance and application data of interest to anyone concerned with electrical insulation—also facts about Fiberglas Tapes, Fiberglas-Insulated Wire and Cable, Fiberglas-Mica combinations and other Fiberglas-base Materials. Write for a copy today, and ask for the name of the supplier located nearest to you.

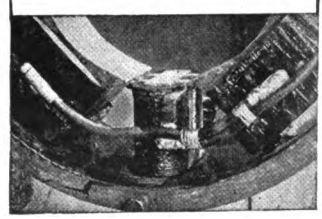
Owens-Corning Fiberglas Corporation, 1860 Nicholas Building, Toledo 1, Ohio.

In Canada, Fiberglas Canada Ltd., Oshawa, Ontario.

There is a FIBERGLAS Insulation Material for every need

Fiberglas Tying Cords are available in sizes from 1/64" to ⅛", in 1/64" increments.

Fiberglas Tying Cords are widely used for banding commutator leads, and over V-ring extensions.



Used most frequently because of its high strength-to-size ratio—as shown in this stator tying application.

Write for catalog EL 44-7, today.

Each distributor of Fiberglas-base Insulation Materials has his own source of supply, since Owens-Corning Fiberglas Corp. does not process these materials.

FIBERGLAS

*T. M. Reg. U. S. Pat. Off.

ARMY E NAVY

ELECTRICAL INSULATION MATERIALS

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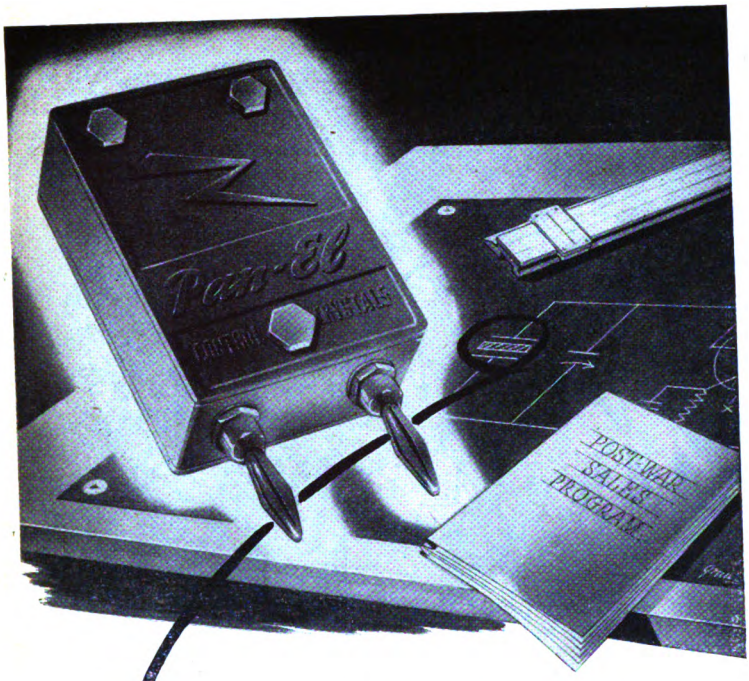


Here's the Heart of Postwar Radio

Crystal-clear reception is a requisite feature to the American public in its postwar radio sets. And crystal control, as you know, is a positive and dependable answer to avoidance of strays, static and other undesirable signal.

Pan-El is ready now to work with any radio, fm or other electronic device manufacturer who knows the importance of engineering crystal control into his postwar circuits. Our staff of Electronic Engineers, veterans now, is always at your service, and eager to help you take full advantage of the quality our crystals can bring to your apparatus. We are in quantity production even of the most difficult types.

PAN-ELectronics LABoratories, Inc.
500 Spring St., N. W., Atlanta, Georgia

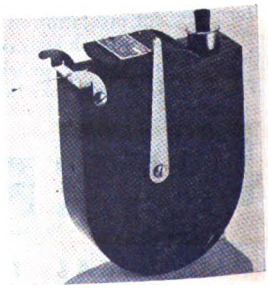
Pan-El
QUANTITY PRODUCERS OF STANDARD AND SPECIAL
Control Crystals

Ionization Gage

PRECISION-TELEVAC ultra vacuum gage, designated as type E-31, is the result of years of research. Electrical leakage is completely eliminated and, when used with a moderately high-speed pumping system, the gage outgasses itself. Filament is automatically protected before and during operation, since current will not enter filament before pressure of 1 micron has been established and turns off automatically if pressure rises above 1 micron. Gages are interchangeable without recalibration and are guaranteed for 1000 hours. Bulletin No. 450-R illustrates and describes a complete line of Televac precision instruments. Precision Scientific Co., 1750 N. Springfield Ave., Chicago 47, Ill.

Recording Galvanometer

THIS GALVANOMETER utilizes a 3-in. long tapered recording pen which is actuated by a permanent magnet penmotor. The pen is Pyrex tipped and records directly in ink (on a moving paper chart) the pressures, vibrations, strains, currents and voltages of frequencies from d.c. to 120 cps. It has no overshoot up to 70 cps at a maximum swing amplitude of 20 mm each side of center line. Frequency response is flat to 70 cps, accurate to 120 cps. The pen can be centered, or raised from



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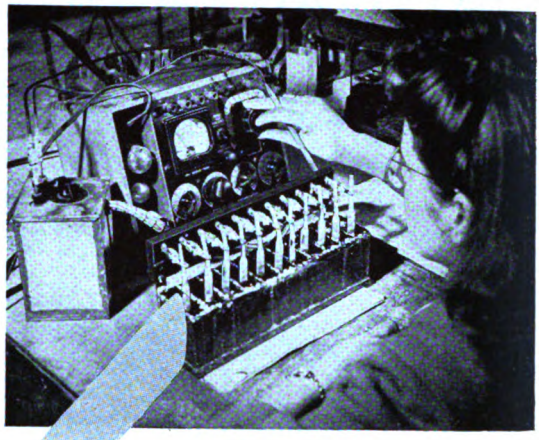
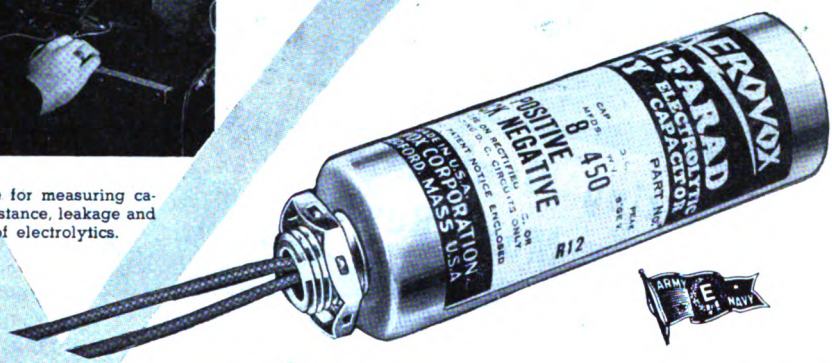
An Aerovox capacitance bridge for measuring capacitance, equivalent series resistance, leakage and other electrical characteristics of electrolytics.

Obtaining the characteristics of aluminum foil samples in order to insure uniform Aerovox quality of each unit throughout production.





✓✓✓✓✓ from START to FINISH insures AEROVOX CAPACITOR Craftsmanship

● Inspection—especially when backed by critical instrumentation—insures Aerovox Capacitor Craftsmanship.

With Aerovox electrolytics, for example, production is checked from *start* to *finish*—from the prechecking of each constituent material used in the production of electrolytics, to the checking of completed units for their electrical and physical characteristics.

Because of the extra-critical inspection standards, most of the test equipment is designed by Aerovox engineers and built in their own engineering laboratories. Hundreds of such exclusive Aerovox instruments are in daily use on the production line—instruments seldom seen outside a laboratory—mounting guard at every step from raw material to finished product.

• • •

It is such outstanding inspection routine, along with skilled and conscientious workmanship, *plus* engineering judgment, that accounts for that widely recognized Aerovox Capacitor Craftsmanship.

● ***Literature on request.***

AEROVOX Capacitors

INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. · SALES OFFICES IN ALL PRINCIPAL CITIES

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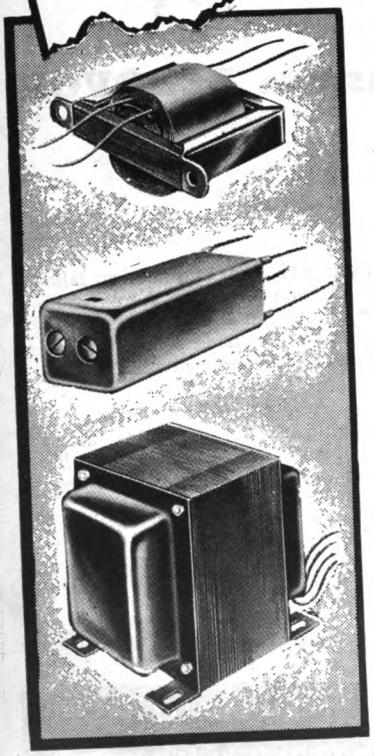
SUPER ELECTRIC

Producing Quality Components on a Mass Basis



Seasoned people — not "Pearl Harbor babies" — are in our production army. For war or peace, Super Electric transformers and radio coils are controlled by the same high quality standards.

Super Electric Products Corp.

1057 Summit Av., Jersey City, N.J.

Transformers for: Power · Audio Frequency · Luminous Tubes

the chart. Impedance of penmotor is 1500 ohms. Maximum sensitivity is 1.1 mm per volt, 1.6 mm per ma, 21 volts full scale. Overall dimensions of the unit are 5 x 4 x 1⅞ in. The Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio.

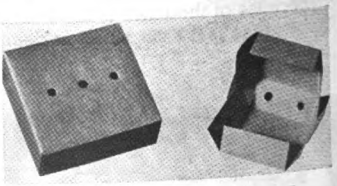
Volume Level Indicator

ALTHOUGH DESIGNED primarily for use across balanced lines, this instrument (designated as Type 920 for low-level indication) will also permit either side of bridged lines to be grounded. The unit utilizes a copper-oxide type indicating meter adjusted for deliberate pointer action, a meter zero-adjusting control and a heavy-duty meter range control variable in steps of 2 vu, 100 to 130 volt, 60-cycle a-c

power supply with voltage regulator to adjust for normal supply variations. Specifications are: range −20 to +20 vu meter reading; extreme range −40 to +23 vu, including full meter scale; standard reference level 1 mw into 600 ohms; variation with frequency is rated less than 0.2 db between 30 and 15,000 cycles. The unit is mounted on a panel for use in standard relay rack. The Daven Co., 191 Central Ave., Newark, N. J.

Component Aid

FOR MANUFACTURERS of capacitors, can liners are available which are fabricated with scores, punches and slits to the exact specifications of the manufacturer. Liners are avail-



able in various insulating papers including drawtex, hitex, beaming kraft, kraftage, fish papers, etc. Howard J. Moore Co., 108 Park Row, New York 7, N. Y.

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DEPENDABLE TROUBLE-FREE OPERATION

The new post-victory line of

SEEBURG RECORD CHANGERS

will have

FEWER MOVING PARTS

BUY WAR BONDS

Awarded to the J. P. Seeburg Corporation for outstanding production of war materials in each of its four plants

ARMY E NAVY

Seeburg

J. P. SEEBURG CORPORATION · CHICAGO

FINE MUSICAL INSTRUMENTS SINCE 1902

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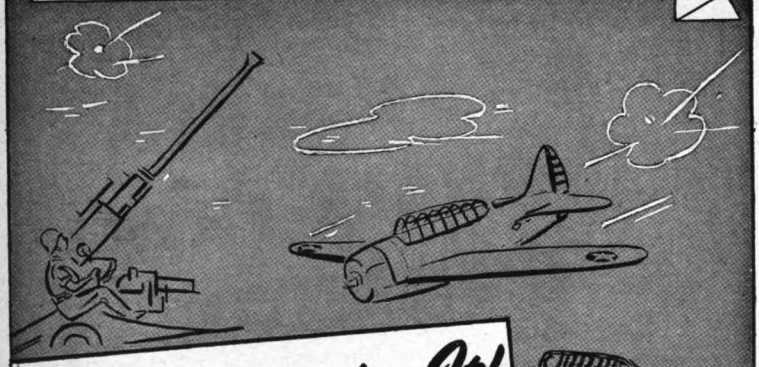
FOR POST-WAR REQUIREMENTS

40 YEARS OF EXPERIENCE AT YOUR SERVICE



Willor Makes It!

... and makes it with a high degree of precision and cooperation born of our concentrated experience in meeting wartime's rigid requirements and schedules. From raw stock to completed items ... Willor service embraces every facility for planned production.

We Invite Inquiries and Blueprints

- METAL STAMPINGS
- MACHINE WORK
- LAMINATIONS
- TOOLS AND DIES
- PANEL BOARDS
- PLASTIC PARTS
- MECHANICAL AND ELECTRICAL INSTRUMENTS

WILLOR
MANUFACTURING CORP.

794 E. 140th St., New York (54) N. Y.

BACK THE ATTACK -- BUY *MORE* WAR BONDS

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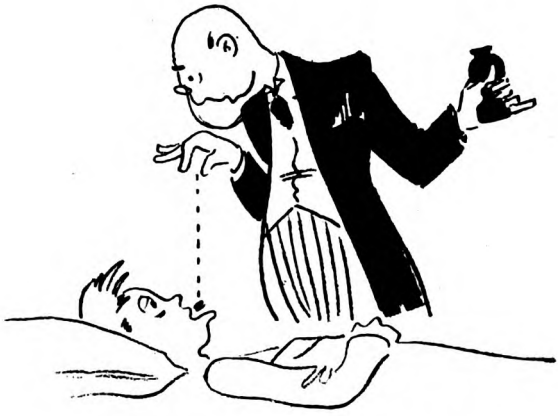

GOOD MEDICINE

for your control or protection problems

KLIXON Snap-Acting CONTROLS

A quick, clean "break" or a solid "make" . . . that's what you get when you use Klixon Snap-Acting Controls in such applications as motor and transformer overheat protection, electrical circuit overload protection, thermal time delays or temperature control for radio equipment. These small, compact, lightweight controls operate surely and accurately no matter how often they operate. Because they have no toggles, or other complicated parts, they give foolproof control or protection even under vibration, shock, motion or altitude. They are available in a wide range of standard types with ratings to meet practically all requirements . . . and in sizes that can easily be incorporated into most mechanical design plans.

Our engineers will gladly help you with your control or protection problems. Write for their services today.

SPENCER THERMOSTAT COMPANY • **ATTLEBORO, MASSACHUSETTS**

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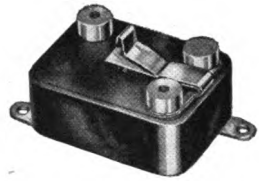
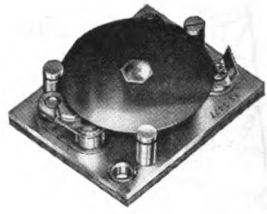


Type C-7220 Precision Snap Switch 12 amps. 30 Volts D. C., 125 Volts A. C.

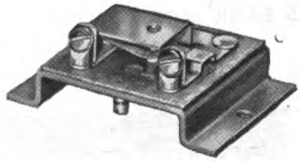
Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.

Type ER Series. Ambient Compensated Time Delay Relays.



Type B-3120 Thermostat and Heater, Crystal Dew Point Control.

Type C-6363 Switch Circuit Breaker



Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

Type RT Thermostat. Adjustable Temperature Control.

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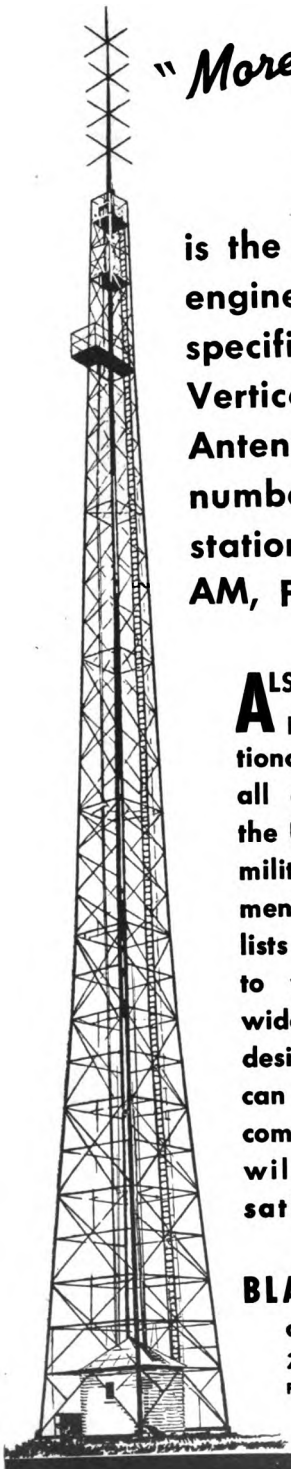


"More than Satisfactory"

is the verdict of radio engineers who have specified Blaw-Knox Vertical Radiators and Antennas for an imposing number of important stations employing AM, FM and VHF.

ALSO, Blaw-Knox has supplied Towers for Directional Radio Beacons to guide all air transport service in the United States, as well as military electronic developments still on the restricted lists . . . For strict adherence to your specifications plus wide experience in structural design and fabrication, you can count on Blaw-Knox to complete a contract which will prove "more than satisfactory."

BLAW-KNOX DIVISION
of Blaw-Knox Company
2077 FARMERS BANK BLDG.
PITTSBURGH PENNA.

BLAW-KNOX VERTICAL RADIATORS

Dual Channel Oscilloscope

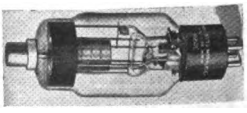
ONE OF THE features of this oscilloscope is that it is possible to observe two separate phenomena on the same cathode-ray tube screen simultaneously without the use of an electronic switch. Two separate channels feed into a single 5-in. cathode-ray tube. Both beams on 100 per cent of the time result in a maximum brightness of trace.

Intermodulation is minimized by the use of two channels which are isolated from each other. The instrument (Model E-2G) can be supplied with a cathode-ray tube having screens of medium persistence green (P1), long persistence green (P2), white (P4), and short persistence blue (P5 or P11). Electronic Tube Corp., 1200 E. Mermaid Ave., Philadelphia 18, Pa.

New Tubes

THREE MANUFACTURERS announce tubes as follows:

Chatham Electronics, 475 Washington St., Newark 2, N. J. Type 3B28 inert gas-filled rectifier tube is rugged and is designed to operate over wide variations of ambient temperature without the use of temperature control devices. Ratings



are: Peak inverse voltage 10,000 volts, peak plate current 1.0 amp; average plate current 0.250 amp; tube voltage drop 10 volts. Filament current is 5.0 amp at 2.5 volts. At 500 cycles or less, the peak inverse voltage rating is 6,500 volts at 2 amp peak plate current, 0.5 amp average plate current. Base is

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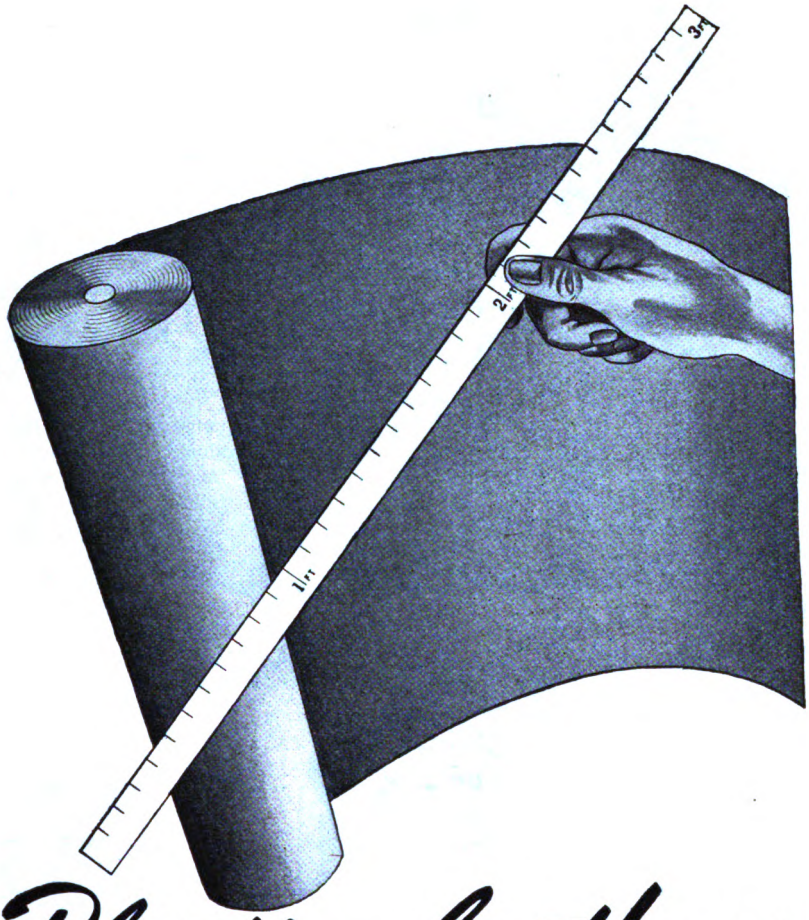

Plastics by the yard

Many types of reinforced plastics are called plastics because the plastic coating or covering bulks larger than the base. Holliston Processed Cloths differ from the usual conception of plastics because the base usually bulks larger than the resin and because the plastic and structural materials are not laminated or combined, but are made integral through impregnating or inter-mesh filling. However, in modernity, utility and effect, Holliston Processed Cloths are special purpose plastics and should be valued as such, even though bought by the yard instead of by the piece or pound.

Think of Holliston Processed Cloths as "flexible plastics" They range in weight from tissue-thin cambrics to coarse, rugged burlap; and possess special functional and or decorative characteristics. They may be folded, creased, sewn or cemented. Consider them as a possible solution of materials problems in postwar planning.

Consult our Research Department.

The HOLLISTON MILLS, Inc.

Processors of Cloth for Special Purposes

NORWOOD, MASSACHUSETTS

Sales Agents in Principal Cities

Cloth Bound

A cloth bound book is bound to be kept — bind your

CATALOG — SALES MANUAL — INSTRUCTION BOOK, ETC.

in HOLLISTON Book Cloth — durable, impressive, hard-to-soil, easy-to-clean.

Write for samples.

Consult your printer.

SPECIAL FINISH

HOLLISTON special finish cloths meet special needs —

TRACING CLOTH — PHOTO CLOTH — RUBBER (PROCESSING) CLOTH — BOOK CLOTH — SHADE CLOTH — SIGN CLOTH — TAG CLOTH.

Cloth combined with special compounds, filled, impregnated, coated — to form a material with characteristics of a plastic and the flexible strength of a woven fabric.

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★ Jet propulsion promises great things for aviation—today and tomorrow. Years of research and experimentation are behind jet planes, which embody the latest advancements in aircraft engines.

Naturally, only materials with the demonstrated ability to meet the rigorous demands of modern aircraft applications are used. We take pride in the fact that C.M.H. Stainless Steel Bellows, both small and extra large, are being used in jet propulsion engines. For C.M.H. is making sure that its products are keeping pace with the changing needs of aviation . . . and other industries as well. Write the Chicago Metal Hose Corporation today for Form SS B 2 on which to submit your bellows requirements. It will save you time . . . assure more accurate transmittal of essential data.

OUTSTANDING FEATURES OF C.M.H. STAINLESS STEEL BELLOWS

- Highly resistant to heat.
- Corrosion resistance of 18-8 Austenitic Stainless Steel.
- Pressure-tight for searching liquids and gases.
- Have the strength for high-pressure service.
- Uni-metal assemblies . . . do away with the hazards of solder.

Flexible Metal Hose for Every Industrial Use

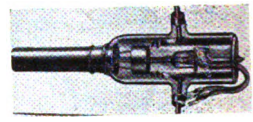
ARMY E NAVY

CMH CHICAGO METAL HOSE CORPORATION
MAYWOOD, ILLINOIS

Plants: Maywood and Elgin, Ill.

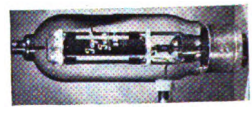
medium 4-pin bayonet type. Top cap.

Amperex Electronic Corp., 79 Washington St., Brooklyn 1, N. Y. Type 233 transmitting tube designed for use as class C oscillator or amplifier or for generating r-f power at frequencies up to 30 Mc. Filament voltage is rated 24 volts;



current 70 amp; thermionic emission 16 amp; amplification factor 52; direct interelectrode capacitance: grid to plate 24 $\mu\mu$f, grid to filament 22 $\mu\mu$f, plate to filament 1.5 $\mu\mu$f.

Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill. Type 822-S high-power triode with a frequency application limitation of 30 Mc. The tube is designed for peak performance in all r-f services, diathermy and class B audio. It may also be used in induction-heating applications. Electrical characteristics are:



Filament 10 volts at 4 amp; amplification factor 30; plate dissipation 200 watts. Interelectrode capacities: grid to plate 13.5 $\mu\mu$f, grid to filament 8.4 $\mu\mu$f; plate to filament 2.1 $\mu\mu$f. Maximum overall length is 9 in. Plate dissipation 150 watts, power output 600 watts, driving power 17 watts.

Multi-band Cathode-Ray Tube

TYPE 5RP (designation assigned by RMA) multi-band cathode-ray tube is of the hot-cathode, permanently-sealed, high-vacuum type and is for use in ultra-rapid writing rates. Subdivision of the intensifier element provides a controlled gradient allowing a total accelerating potential of 17,500 volts to be employed with only slightly reduced deflection sensitivity. The tube permits recording at writing rates in excess of 2500 km/sec (using a 35-mm camera with an f 1.9 lens) corresponding to sine-wave transients at 40 Mc. Allen B. DuMont Labs., Inc., 2 Main Ave., Passaic, N. J.

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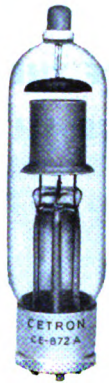
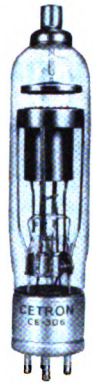
The Complete Line
OF RECTIFIERS AND PHOTOTUBES
CETRON

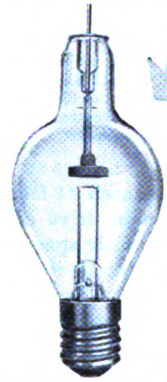
Particularly sensitive to blue and violet light. RMA spectral sensitivity designation S-4. 5-Pin base interchangeable with other similar tubes.



Rectifier designed to meet rigid Army and Navy specifications. Incorporates numerous improvements insuring efficiency, ruggedness and long-life.



Grid control Rectifier (Thyratron) especially suited for industrial use, such as handling primary currents of small resistance welders—motor control, etc.



CE-235 is a half wave Argon-filled Rectifier with screw base, sturdily constructed for long, dependable service.

Cetron Rectifiers are available in gas and mercury filled, both full and half wave types in a wide range of ratings.

Cetron Phototubes are produced by us to take care of almost every situation . . . over 50 types, both blue and red sensitivity.

Continental's long experience and careful production methods insure you the utmost in satisfaction from all the many types of tubes we make. Write for complete catalog.

CONTINENTAL ELECTRIC COMPANY GENEVA, ILL.

★ CHICAGO OFFICE, 188 W. Randolph Street
NEW YORK OFFICE, 265 West 14th Street

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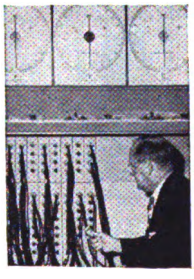
One of the fans in the cooperative wind tunnel—owned by Consolidated Vultee, Douglas, Lockheed and North American—operated by the California Institute of Technology.

CANNON PLUGS IN ALL CIRCUITS OF THE CALTECH WIND TUNNEL

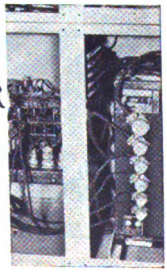
Two fans, each 21 feet 9½ inches in diameter, with a main drive of 12,000 hp. maximum, develop an air speed of over 700 m.p.h. in this new aircraft testing machine. Models are tested under air pressures ranging from one-quarter atmosphere to four atmospheres. Aerodynamic forces and moments are measured accurately, readings automatically recorded.

More than a thousand Cannon Connectors are employed in the electric circuits of the installation. Their use makes possible the quick and easy interchange of equipment, eliminates the duplication of costly instruments, increases the accuracy of the records taken.

Cannon Connectors, available in many thousands of standard capacities, sizes and types, may serve well in the circuits of the instruments you use or the products you manufacture. Write for a Condensed Catalog. Cannon Electric Development Co., Dept. A-120, 3209 Humboldt St., Los Angeles 31, California.



Above: Measuring dials recording forces and moments through control panel of Cannon Connectors. *Left:* Special Cannon Connector for portable control and recording unit. *Below:* Cannon Plugs used on measuring and recording machines designed and installed by International Business Machines Corporation.



CANNON ELECTRIC

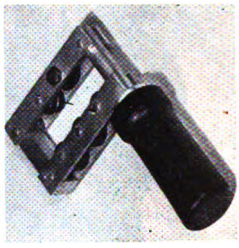
Cannon Electric Development Company, Los Angeles 31, California

Canadian Factory and Engineering Office:
Cannon Electric Company, Limited, Toronto

Representatives in Principal Cities—Consult Your Local Telephone Book

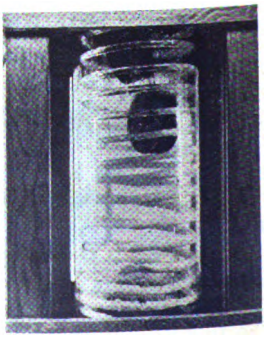
Coaxial Cable Grooving Tool

ILLUSTRATED IS a coaxial cable grooving tool which is designed to expedite the work of radio engineers and maintenance men. It makes better soldered splices in ¾-in. coaxial cable and can also be used to make strong soldered joints on ¾-in. diameter tubes used in plumbing, heating and refrigeration. Easy and fast to operate, the tool makes spun-in grooves in the splicing sleeve that grip the outer conductor firmly. This operation makes a secure joint and prevents the solder from entering the cable. Easily replaceable cutting wheels are used to cut the outer conductor. Andrew Co., 363 East 75th St., Chicago 19, Ill.



Selenium Rectifiers

TYPE K SELENIUM rectifiers which do not show any effects of salt spray after 100 hours of operation at 50 deg C are announced by Selenium Corp. of America, 1719 W. Pico Blvd., Los Angeles 15, Calif. The manufacturer has used a new method of assembly and coating technique. The new coating protects the selenium barrier layer from within and preserves its rectifying properties indefinitely. It also protects the barrier layer from exterior attacks by salt spray, fungi, mercury vapor and other



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GAS AND RESISTANCE WELDING • STAMPING • ELECTRICAL WORK

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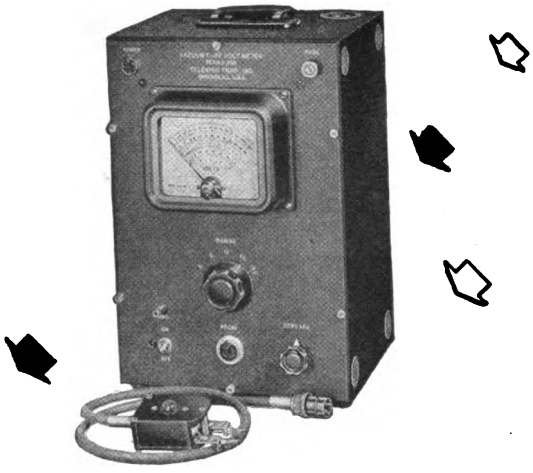
WAR RESTRICTED DEVELOPMENTS



Now Available

in TELEVISO Series 200A Vacuum Tube Voltmeter

TELEVISO, pioneering in the production of measuring apparatus for the **SONIC to UHF SPECTRUM,** has specialized in building dependable Vacuum Tube Voltmeters.

A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable.

FEATURES:

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural.); sub-chassis is ⅛" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.

ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shortening of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the field. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts ac. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago.

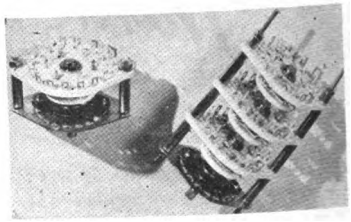
Televiso Products Inc.

7466 IRVING PARK ROAD CHICAGO 34, ILLINOIS

corrosive fumes. Recent tests by the manufacturer consisted of a 3-min spraying of the selenium rectifiers with a 20 percent salt solution at 55 deg C, followed by a 3-min air blast at 55 deg C, the cycle being repeated continuously throughout the entire 100-hr test. A strong ultra violet light was continuously played on the rectifiers during the length of the test. Results showed no corrosion nor variation in electrical characteristics. The illustration shows the rectifiers suspended in a salt-spray testing tank.

Medium-Duty Power Switches

CENTRALAB'S new "J" switch series for power applications for transmitters are in production and will be available from stock, in one to five sections, with shorting or non-shorting type contacts. In addition to complete units, sections and indexes will be available separately for individual assembly in any de-



sired combination. All units will be furnished with adjustable stops for limiting the desired number of positions. Switches will have single-hole bushing mounting, with tie-rod extensions to act as locating keys and for additional support in mounting. Bulletin No. 185 is available. 900 E. Keefe Ave., Milwaukee 1, Wis.

Vacuum Tube Voltmeter

A NEW, COMPLETELY universal vacuum-tube volt-ohm-milliammeter is announced by McMurdo Silver Co., 1240 Main St., Hatford, Conn. The instrument is called "Vomax" and has 12 d-c voltage ranges (0.05 through 3000 volts) at input resistances of 50 and 125 megohms. Six a-c voltage ranges cover 0.05 through 1200 volts, all at 6.6 megohms and 8$\mu\mu$f input loading. Three of these ranges are calibrated -10

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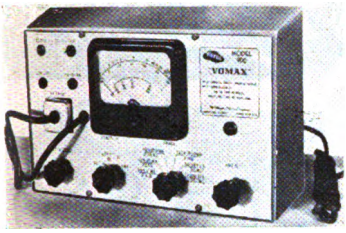
through +50 db for power output measurements. Six d-c ranges facilitate measurements from 50 mi-



croamperes through 12 amperes. Six zero-left resistances ranges cover 0.2 ohms through 2000 megohms. The a-c response is flat to 5 per cent over the range of 20 cycles to above 100 Mc. One zero-set knob serves for all ranges and need be set but once for all 39 ranges. The instrument has only five different scales on the 4½-in. meter. All circuits are dual-tube, automatically balanced against line voltage variation and tube aging. A removable diode r-f probe is used in the instrument.

Limits Bridge

MODEL 81 LOW-RANGE limits bridge is self-contained and is one of a series of units for the rapid comparison of large quantities of resistors having comparable values. It is manufactured by Associated Research, Inc., 231 S. Green St., Chicago 7, Ill. The unit is capable of testing resistance values up to

2000 pieces an hour, and any item that offers ohmic resistance to flow of current can be tested. The instrument is battery operated and extremely flexible. The overall adjustable range is from ¼ ohm to 10,000 ohms. Sensitivity control range is from plus or minus ¼ per cent to plus or minus 10 per cent. the unit measures 8x8x12 in. and weighs 18 lb.

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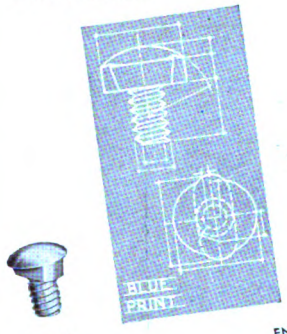
ANOTHER SPECIAL BY PROGRESSIVE

QUALITY PROMCO BRAND



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CATALOG SHOWS DOZENS MORE

Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, dec. equivs. of fractions, other purchasing and engineering helps. Write for Catalog 18.

The PROGRESSIVE MFG. CO.

50 NORWOOD ST. TORRINGTON, CONN.

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AMPERITE

THERMOSTATIC METAL TYPE

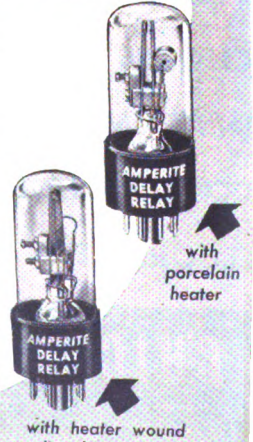
DELAY RELAYS

PROVIDE DELAYS RANGING FROM 1 TO 120 SECONDS

Other important features include:—

1. Compensated for ambient temperature changes from —40° to 110°F.
2. Contact ratings up to 115V-10a AC.
3. Hermetically sealed — not affected by altitude, moisture or other climate changes . . . Explosion-proof.
4. Octal radio base for easy replacement.
5. Compact, light, rugged, inexpensive.
6. Circuits available: SPST Normally Open; SPST Normally Closed.

WHAT'S YOUR PROBLEM? Send for "Special Problem Sheet" and Descriptive Bulletin.



with porcelain heater

with heater wound directly on blade

AMPERITE CO. 561 BROADWAY NEW YORK 12, N. Y.

In Canada: Atlas Radio Corp., Ltd.
560 King St. W., Toronto

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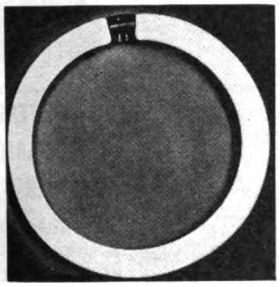
Fluorescent Tube Achievement

LAMP ENGINEERS who developed the circle of light known as the circline fluorescent tube topped off their achievement by making both ends meet with a 4-pin plastic base (at top of lamp.) The new base is

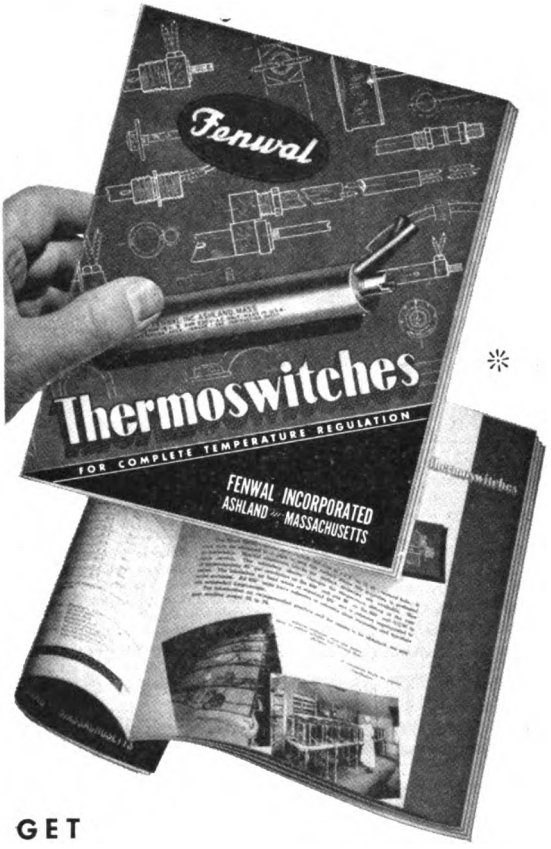


shown on the 12-in. ring, the medium-sized member of the family of three circlines which the Westinghouse Lamp Div., Bloomfield, N. J. will offer as soon as wartime manufacturing conditions permit. This base, about 1 in. in diameter, contains two pins from each of the two connecting ends of the lamp. For convenience in installation the pins are mounted at a 45-deg angle to the plane of the circle.

Recording Densitometer

DESIGNED TO READ densities from zero to 4.0, this instrument is particularly useful for speedily detecting variations in photographic or radiographic film. However, the principle of operation can be utilized in any field where variations in the subject can be detected by elec-

tronic apparatus. The densitometer computes a true logarithmic graph of its findings. The instrument was designed and built by the Electrical Research Div. of Western Electric Co. and Leeds and Northrup Co. to meet specification requirements developed by Triplett and Barton, Inc., Burbank, Calif.



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On Temperature Control

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TO AIRCRAFT DEVELOPMENT ENGINEERS

Before deciding on temperature regulating devices for your products, be sure to investigate Fenwal Thermoswitches. They operate on an unusual principle, and offer many advantages not found in other types of switches. The Fenwal Engineering Data Book contains detailed drawings of construction of various models and typical installations.

- Compact construction permits installation in tight places.
- Make and break unaffected by external vibration.
- Readily adjustable for wide range of temperature control.
- Minutely accurate.
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- Inexpensive.

A 44-page treaties on Thermal Control including installation drawings, photographs, blueprints and descriptive suggestions for future planning with basic principles involved in temperature regulation and control. . . . Just write for your *free* copy on your business letterhead.

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THERMOSWITCHES
Fenwal, Inc.
FOR COMPLETE TEMPERATURE CONTROL
43 Pleasant Street, Ashland, Massachusetts

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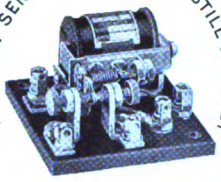
"KURMAN SENSITIVE" OF 1930 - STILL THE BEST



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KURMAN RELAYS

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The Well-Known
KURMAN SENSITIVE RELAY

the first to demonstrate the superior magnetic properties of hydrogen-annealed nickel alloy 15 years ago —again introduces an outstanding new feature:—

CHATTERLESS OPERATION

— obtained through cushioning of contacts in an energy absorbing material. This feature enables keying up to 150 words p. m. Mica insulation of the armature makes the relay suitable for keying 50 m. c. RF signals.

25 YEARS' EXPERIENCE, a thoroughly competent staff of Development and Design Engineers, and complete manufacturing facilities are at your service when you submit your Relay problems to us.

For trouble-free operation in any climate and at any desired altitude,

HERMETICALLY SEALED

relays are available, either of plug-in type or equipped with solder lugs. Some of these relays take as little space as 2" x 1¼" dia., and have up to 10 amps current capacity due to the special atmosphere introduced into the container under pressure.

Write for details on:
KURMAN LINE OF RELAYS
KURMAN VIBRATOR CONVERTERS
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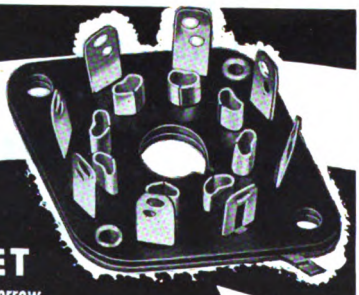
KURMAN ELECTRIC CO.
35-18 37th STREET • LONG ISLAND CITY 1, N. Y.

INVESTIGATE
Franklin's 39
RADIO SOCKET
The favorite yesterday, the favorite for tomorrow



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LAWTON
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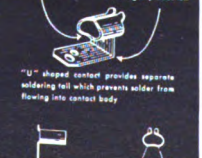
Note—Ground Tab

Illustrating the "U" shaped bow spring action contacts...39H and 39G...used in Franklin's series 39 Sockets.

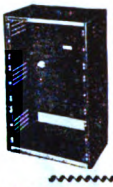


- A W FRANKLIN MANUFACTURING CORPORATION
  Sockets . . . Terminal Strips . . . Plugs . . . Assemblies
- F W SICKLES COMPANY
  Coils...I. F. Transformers...Antenna Loops...Trimmer Condensers, mica and air dielectric . . . Tuning Units
- ELECTRO MOTIVE MANUFACTURING COMPANY
  Molded Mica Capacitors...Mica Trimmer Capacitors

Hard to Get?
HARRISON has it!

Harrison usually has for immediate delivery, appropriate stocks of critical Electronic Parts and Equipment

RACK CABINETS



8¾ to 77" panel space. Also a complete stock of chassis, panels, rack accessories and smaller steel cabinets.

HALLICRAFTERS
S-39 PORTABLE
RECEIVER

AC—DC—Battery
9 tubes, 540 KC to 30.5 MC
$110 complete.

MULTIMETERS

Triplet 1200-E
SUPREME 542
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Moderate quantities of all stock current ratings. Also Holders and Extractor Posts.

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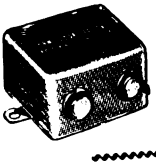
1 MMF to 4000 MFD
6 Volt to 25 kilovolt



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Harrison service is the byword of the Electronic Industry — Serving faithfully since 1925

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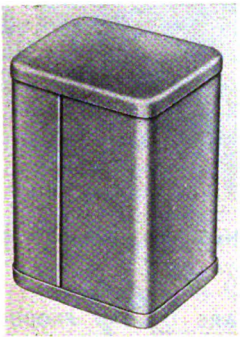
Transformer Cases

A NEW LINE of standard size transformer cases is available in quantity. Sizes range from 1¾ x 1⅝ x 2⅛ to 5⅞ x 4¾ x 6¾ in. They can be furnished with or without studs,



pierced covers, brackets or channels. Olympic Tool & Mfg. Co., Inc., 39 Chambers St., New York 7, N. Y.

Portable Kilovoltmeter

A NEW ADDITION to the line of portable kilovoltmeter made by the Shallcross Mfg. Co., Collingdale, Pa., is known as No. 759. This instrument has 5 ranges that provide 1, 2, 5, 10 and 20 kilovolts d.c. at full scale. The accuracy of the built-in meter is plus or minus 2 percent. Several new features are incorporated in this instrument.

Vacuum Tube Voltmeter

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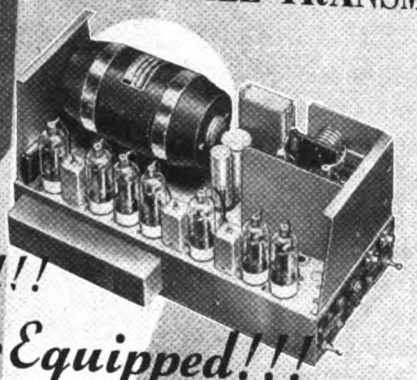

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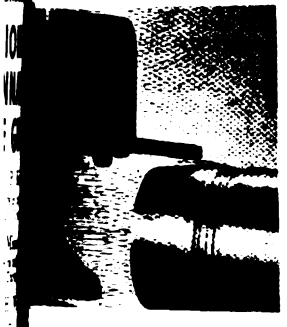

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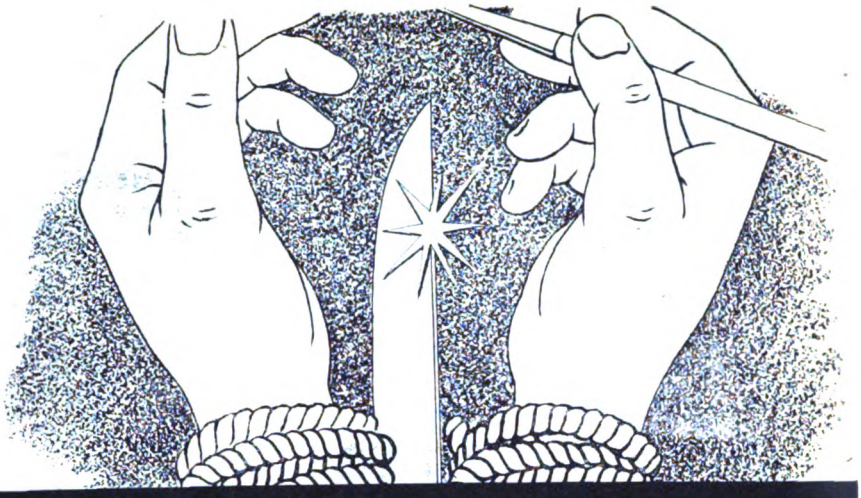

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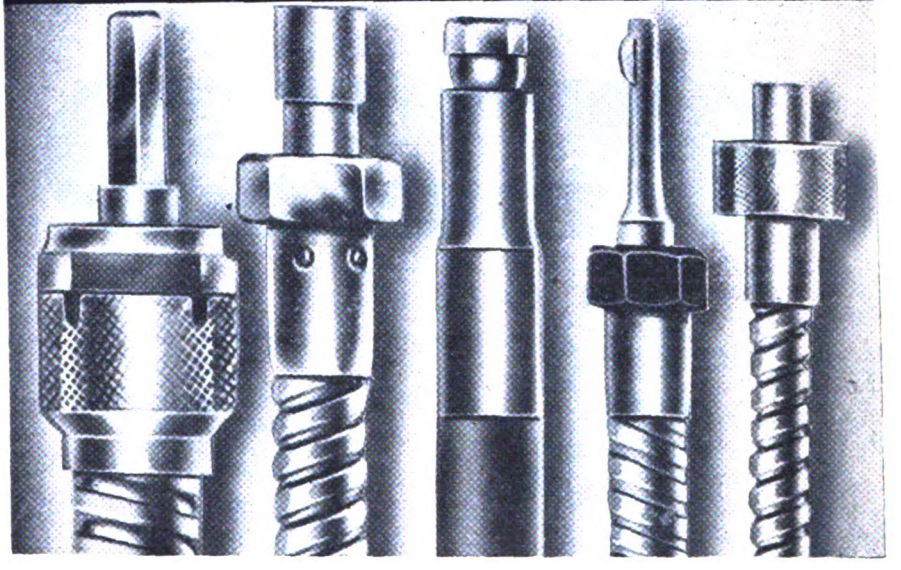

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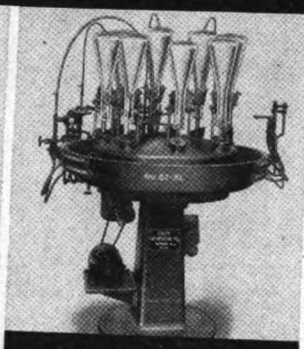

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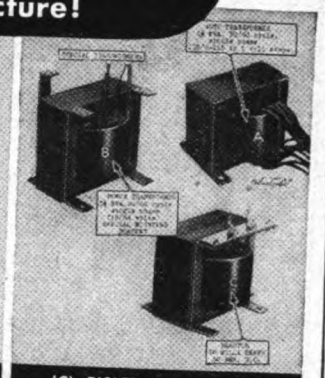

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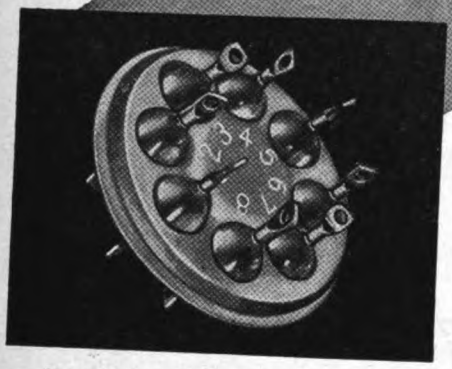

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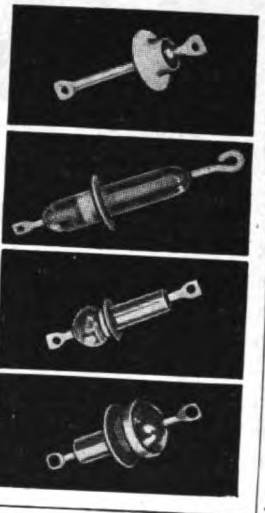

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Lighthouse Tube. The theory evelopment of the Lighthouse (disk-seal electronic tube) is ined in publication No. ETR-7. pamphlet describes the basic ples of design and operation e tube and its advantages in sion, f-m and other fields in -h-f spectrum. General Elec- Co. Tube Div., Schenectady.

ys. Catalog No. 10 gives illus- ons, fully detailed specifica- , suggested applications and ting data of the most widely relays, solenoids, magnetic cts and switch parts manu- red by Guardian Electric Mfg. 1400 W. Washington Blvd., Chi- 7, Ill.

ording Apparatus. The several of recording apparatus for recording of pressure, temper- e, time (on-off) or any process reaction is contained in a 28-page klet released by Gorrell & Gor- Chicago Heights, Ill., manu- urers of "Electrix" recording er.

acuum-Tube and Crystal Rectifi- s in UHF. A recent copy of The perimenter, published by Gen- al Radio Co., 275 Massachusetts ve., Cambridge 39, Mass., contains article entitled "Vacuum-Tube d Crystal Rectifiers as Galvano- eters and Voltmeters at Ultra- igh Frequencies."

apacitors. The background, uses types of capacitors is contained a 40-page brochure which also as color illustrations depicting the es of capacitors in war equip- ent. The brochure is entitled ilar Capacitors in the War and the Peace." Solar Mfg. Corp., 6 Madison Ave., New York 17, Y.

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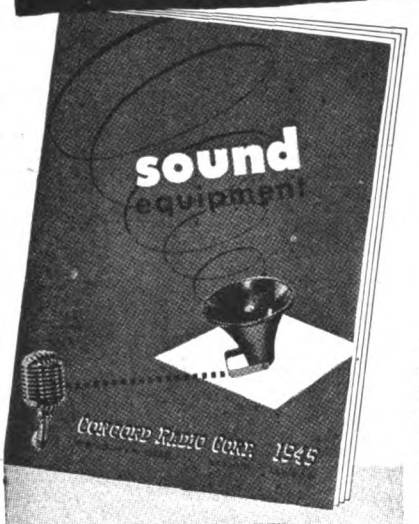

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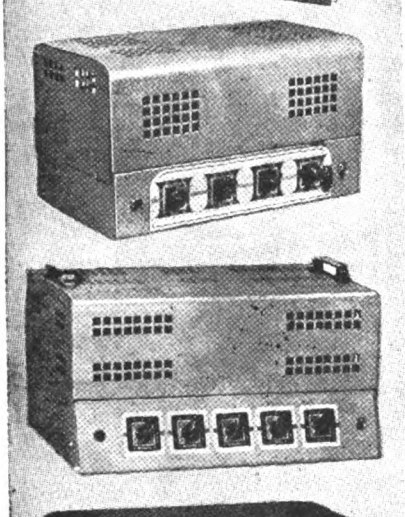

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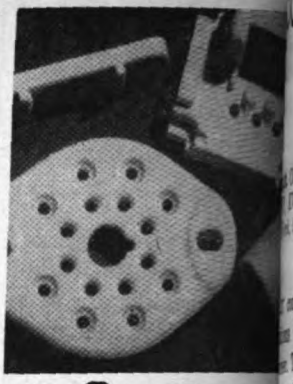

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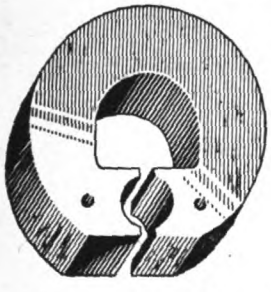

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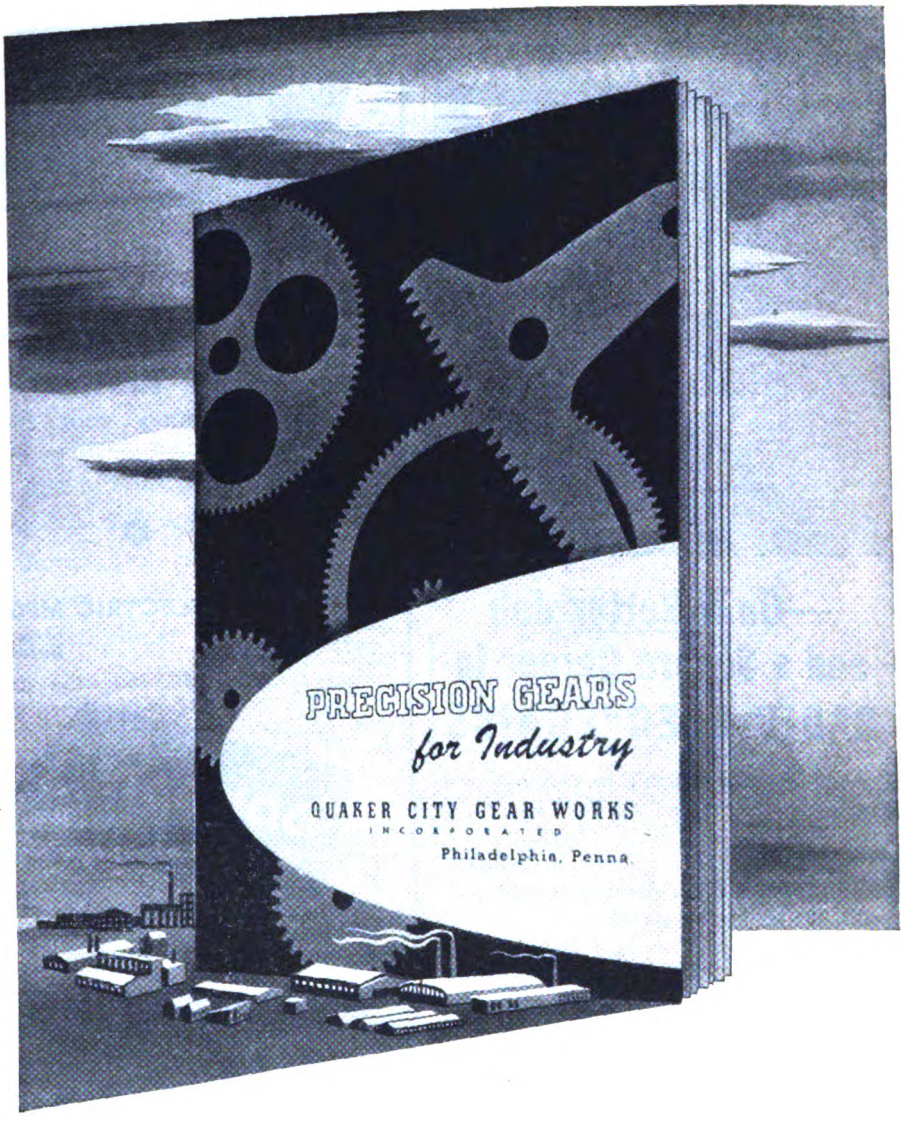

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eir mathematical name so
e reader can readily follow
being done, and has asso-
he text description with the
al work.

eral, however, the mathe-
discussions suffer from
Arithmetic, it is ex-
on page 15, deals with
d with the operations of
subtraction, multiplica-
division, and does not
negative numbers (this
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inconsistency of dealing
digits and yet using divi-
on which fractions will
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bers yet using subtraction
in itself deals with nega-
mbers and frequently pro-
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in more precisely written

overall presentation is that
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s and mathematical proc-
As an illustration of this
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$$C = \frac{.0885KA}{10^8 \times t}$$

capacitance in microfarads
dielectric constant of di-
c

area of the dielectric in
centimeters

thickness of the dielectric in
eter (1 inch = 2.54 centi-
)"

h arbitrary information is
s. The educational value of
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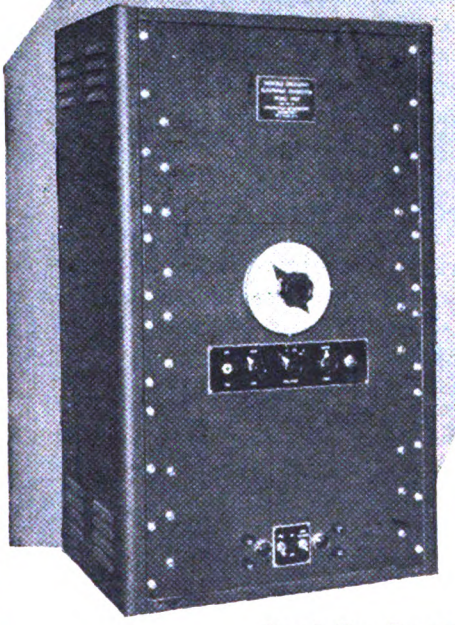

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metic from *this* book, but *if* he hopes to learn through *understanding* he had best look elsewhere for an introductory work. This criticism is not directed solely at this book. Altogether too many books are being published today on technical subjects that *do* not explain; they merely describe. A 300-page list of arbitrarily stated facts, useful as they may be if understood, does not constitute an introduction to radio.

What is needed in this and other growing technical fields is not technicians who do thus and so because they are told to, but young men who can be given the responsibility to do the job because they understand the fundamentals. It is the function of an introductory book to explain those fundamentals; there is plenty of space in service manuals for dictatorial instructions.

Nor need it be feared that technicians cannot learn by explanatory treatment. Rather—and this has been the experience of this reviewer in teaching technicians at night school—they do not want the *what* without the *why;* they retain the information longer if they have a sound understanding of why it is so. They can—and would rather—learn the right reason instead of some simplified but false or incomplete explanation.

The book is well edited and adequately illustrated. The clear typography and pleasing type face make it readily readable. Boldface paragraph headings, and italic key words and important statements assist greatly in orienting the reader and emphasizing the material.—F.R.

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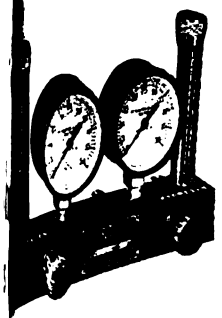

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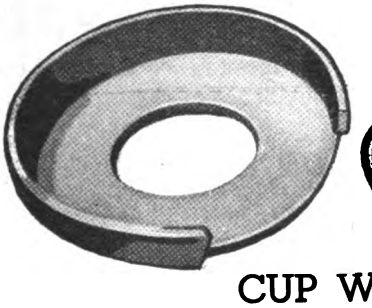

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published

On Mitogenetic Radiation

Dear Sir:

I HAVE JUST come across O. C. Gruner's (ELECTRONICS, Dec. 1944,) paper on A Neon-counter for Medical Research and feel obliged to address one or two remarks to you on the subject.

The author states that "Hollaender and other physicists decided that mitogenetic radiation does not exist at all." This is not so. Hollaender examined the problem fairly and came to the conclusion that the evidence for the existence of mitogenetic radiation is not sufficiently convincing at present to be generally acceptable. This is a conclusion which, as far as I know, has not been challenged by any responsible authority. A recent survey made by Moiseeva, has led to the same conclusion.

The author states that "the Geiger counter failed to reveal conclusive evidence of these radiations, but it was thought that a neon counter might serve the purpose." Since a Geiger counter, properly used, will permit the detection of a single ionized particle, it has a very much greater sensitivity than any other device in the ultra-violet region, where most of the mitogenetic radiation is supposed to occur.

The author states that "If the material to be studied emits a radiation which adds to the potential (of the neon lamp), the beats of discharge will become more frequent; if the material interferes with the accumulation of potential, the beats will slow down." This statement reveals a curious ignorance as to the operation of the neon-tube relaxation oscillator. If ionizing radiation passes through the space between the electrodes of the tube, the ions produced may cause the capacitor to discharge more quickly, but no amount of radiation could possibly increase the potential of either electrode. It is, however, well known that

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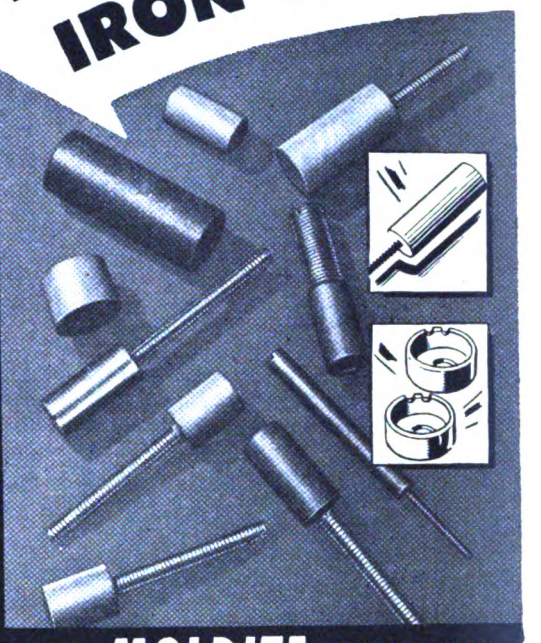

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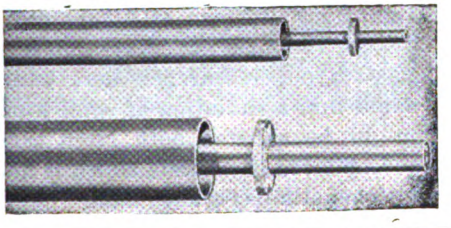

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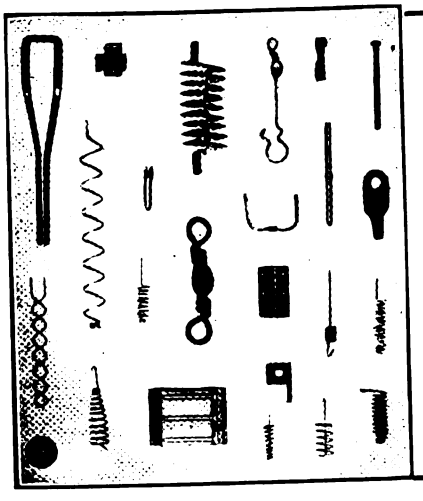

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toplasma Monographien, 1936, vol. ix), especially pages 91 and 92. As to the last paragraph of Mr. Lenihan's comments, one may mention the work done at the Roffo Institute at Buenos Aires (details of which were published since the experiments were made here). A very close study of the carcinogenetic radiation from sterols in cancer was made by undoubted experts, and besides other methods of investigation, a neon counter was devised for the purpose.

Maybe the object of the work is misunderstood. There was no idea that this counter refutes Hollaender's conclusions, or challenges them or any responsible authority. Its construction originated in the desire to arouse the interest of electronic experts in an important field of clinical investigation, aware that an actual instrument provides a preliminary demonstration, from which they might proceed to something of wider scope in this branch of medical research.

O. CAMERON GRUNER
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Audionics

My dear Henney:

I HAVE BEEN very remiss in not having long ago expressed to you my natural and very deep gratification over the cover of ELECTRONICS in April.

There indeed is a notable example of the truth of the old Chinese adage: "A Picture Is Worth 10,000 Words."

Your photographer selected for this picture a beautiful sample of one of the early Audions, I think of the 1909 vintage. Earlier types included only a single plate and grid.

With best wishes to ELECTRONICS, and regards to its editor.

LEE DE FOREST
Experimental Laboratory and Inventory
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• • •

About Turnovers

Dear Sirs:

CONGRATULATIONS on the new arrangement of editorial matter in June 1945 issue. Having all of the article appear consecutively makes reading much easier, and is a tremendous help when it comes to binding ELECTRONICS.

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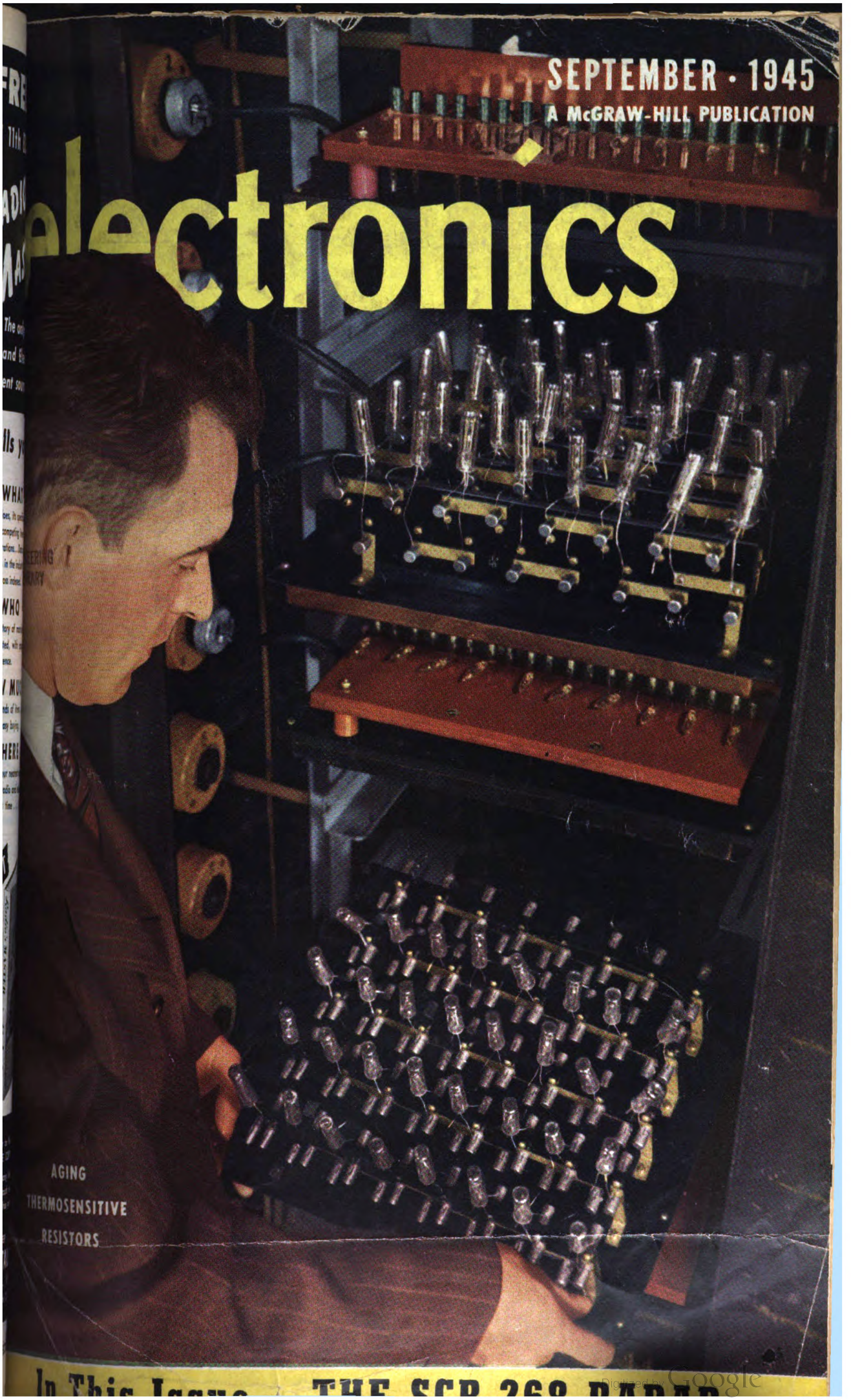

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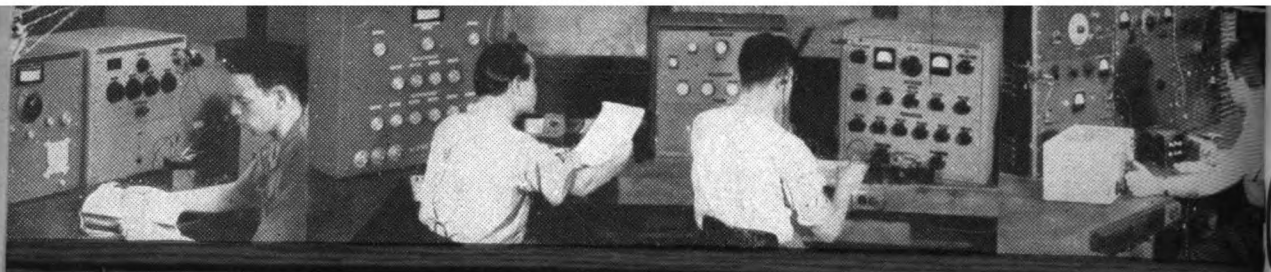

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CROSS TALK

68 . . . With this cryptic title, the Signal bels its first radar set designed in the Signal aboratories at Fort Monmouth under the gen- ction of General (then Colonel) Colton, built tern Electric, operated by the Army here, nd everywhere in the dark early days of the ow completely declassified, the 268 is ade- described for the first time in this issue of NICS. The manuscript has been in our safe for properly passed by the Office of Censorship. definite policy on publication of radar infor- had been formulated, however, the War ent felt that the article should not be pub- spite of the fact that the set had been com- d by both Germany and Japan months ago and of the fact that more modern versions of radar the 268 in every respect.

ost of ELECTRONICS' readers know, a previous xisted in which radar as a subject could be ed in print. Then censorship clamped down ard, because too much was mentioned and im- print and because of the incipient triangular r who developed radar—the Americans or the the Army or the Navy, this laboratory or that ieing with each other in making claims in ing, manufacturers threatened, collectively, to ay too much information; and so nothing what- ld be said for quite some time.

. in Chicago, labor troubles developed. More were needed to make parts and assemblies radar. Manufacturers wanted to state in print s on radar were waiting. New permission was to use the term publicly provided there was ion of how radar worked or what it did.

this mystery whetted the appetite of the pub- publishers, and of anybody else whose curi- as easily intrigued. Here was something new, ng wonderful, and—above all—something hot. eantime, the SCR-268 had served its purpose; captured with blueprints and operators, had ade obsolete by new research.

There is one other bit of history that should be known. In the summer of 1940, English scientists came to this country looking for help. They put their cards on the table, telling American scientists everything that England had up its sleeve in exchange for information on our new defensive and offensive devices. They asked one thing—that nothing be published about these matters until the British were ready because English law makes it impossible to protect oneself by patent on any device that has been described in print.

The first break in the dam preventing more adequate publication of radar principles came when R. L. Smith-Rose published two papers on the subject in the *Wireless World* of London. Since then, considerable effort has been made to relax censorship on the whole subject so that the principles can become known and can be put to much wider use than in purely military devices.

An agreement has now been reached on radar. Other policies have been established which will permit more rapid and complete publication of data on all our wartime research. Thus much of the fine work carried out by hundreds of the nation's best scientists under OSRD will become available to the credit of those who, valiantly and silently and without acclaim, have labored so long behind locked doors. Much of their research will have direct application to industry and communications.

Other articles similar to the present SCR-268 story and much of the hitherto secret wartime electronic developments accomplished under OSRD will see daylight through the editorial pages of ELECTRONICS.

► U-235 . . . There have been many best-kept secrets of the war, but none approaches the Manhattan Project, the cloud under which the Army obscured its work on the atomic bomb. News of the bomb was released just as this issue of ELECTRONICS went to press. The basic background, however, was published in our July 1940 issue and is reprinted in the Electron Art department this month.

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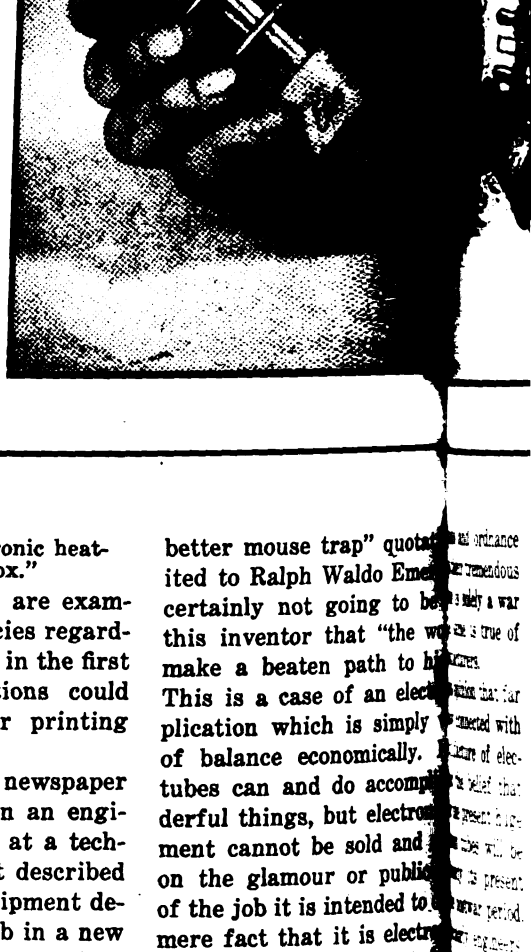
Postwar ELECTRO B

Potential demand for receiving, transmitting and industrial types is estimated and compared with the best prewar year. The outlook for complete electronic equipment in both old and new categories is simultaneously discussed



By W. C. WHITE
Research Laboratory
General Electric Company
Schenectady, N. Y.

A FEW MONTHS AGO there appeared in a leading New York City newspaper the following two-column heading: "Electrons Now Make Huge Propellers For Our Warships in 700 Percent Faster Time."

At about the same time, a well-rated popular-science magazine enjoying a wide circulation contained the following item:

> "Electronic rat trap operates when a rat passing through an open tunnel cuts an invisible ray beamed on a photocell. Trap doors drop down at both ends and the rat, seeing light above, goes up a ramp to a small chamber where he steps on a switch plate which turns on a current to electrocute him."

Also, the writer recently received a letter which read as follows:

> "It has been proposed to convert a certain amusement park steam locomotive from a coal burner to an oil burner on account of the smoke and cinder nuisance.
>
> "The miniature railroad is located in the . . . area, the gage of track is 16 inches and the locomotive and tank weigh about one ton in working order.
>
> "My object in writing to you is to inquire if instead of using oil as a fuel to generate steam it would be either possible or practical to install an electronic heating device in the fire box."

These three instances are examples of present-day fallacies regarding electronics, although in the first two cases the publications could hardly be criticized for printing them or featuring them.

The first case, the newspaper heading, was a report on an engineering paper presented at a technical society meeting. It described an elaborate piece of equipment designed to do a difficult job in a new and better way. If one examines the paper in detail, however, it is to be noted that only one electron tube is used per unit. The tube could be one of the so-called receiving types and certainly would not cost over five dollars. This is a case, therefore, where the amount of tube business involved is negligible, particularly as the industry and operation covered by this electronic application could not possibly require more than a relatively few equipments.

The rat trap described in the second item would undoubtedly catch rats and might be technically satisfactory. However, in spite of "the better mouse trap" quot... ited to Ralph Waldo Eme... certainly not going to be... this inventor that "the wo... make a beaten path to h... This is a case of an elect... plication which is simply ... of balance economically. ... tubes can and do accomp... derful things, but electron... ment cannot be sold and ... on the glamour or public... of the job it is intended to ... mere fact that it is electr...

The third case is typica... mass advertising and ... have impressed the layman w... unlimited possibilities of ele... ics.

Wartime Phenomena

Admittedly, these are some... extreme examples, but to a ... degree they have appeared ... dreds of times in print over th... few years. They must have ... many men and concerns to lo... the future business possibili... electronics, particularly the ... facture and sale of electron... the heart of such devices.

During wartime the ...

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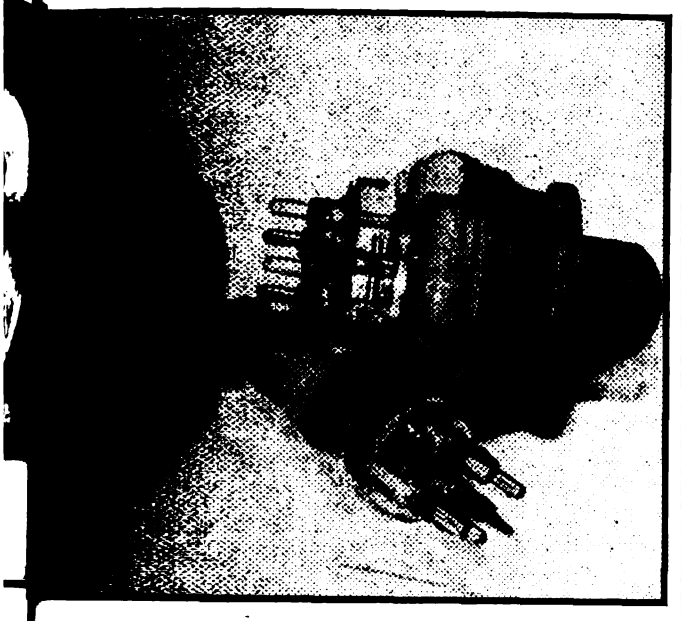
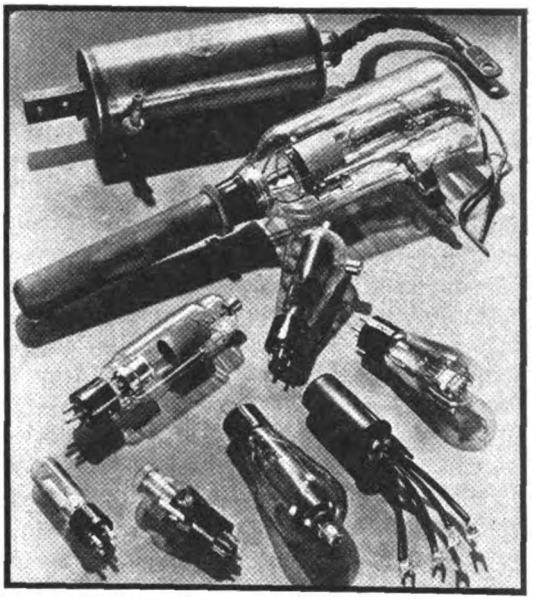
UBE BUSINESS





of munitions and ordnance know that their tremendous of business is solely a war enon. The same is true of craft manufacturers.

the writer's opinion that far ny men now connected with le and manufacture of elec- ubes harbor the belief that w or other the present huge for electron tubes will be ined at nearly its present during the postwar period. men, particularly engineers, ve been active optimists and astic promoters of elec- over the leaner years still their faith and enthusiasm ow, in comparison with the ners, are considered cynical imistic. What the layman es forgets is that electron re not consumed directly but old only for installation in uipment or as replacements bes that have ended their life in equipment being op-

ld War II has been charac- d by the vast number of en- -driven units, such as tanks, s and landing craft, that are being used. In total, these are known to number many hundreds of thousands, and each has at least one complete radio transmitter and receiver.

In the case of radio transmitting tubes, there are two factors that have inflated the tube requirements beyond the wartime increase in apparatus using them. The first of these arises from the fact that the useful life of electronic equipment in wartime is bound to be much shorter than the obsolescence life in normal use. Experience has indicated that commercial electrical equipment is capitalized on a basis of 10 to 20 years. The life expectation of radio equipment in wartime is probably more like these figures in months rather than in years.

The second factor is the large number of spare tubes that must be manufactured for each socket put into use. This is largely due to the fact that we are engaged in a global war. Tanks, planes and ships may have to be used and serviced in huge numbers in dozens of localities widely scattered throughout the world. Therefore, spare and replacement tubes have been produced and distributed in a ratio far exceeding that required for normal or peacetime electronic devices.

This enormous war inflation is indicated in the case of the Navy by the following paragraph from a paper by Captain J. B. Dow, Director of the Electronics Division of the Bureau of Ships:[1]

> "At the end of December, 1941, the Navy comprised a total of 2082 vessels and landing craft, in each of which at least one transmitter and two receivers were installed. As of December 1, 1944, this figure had risen as a result of the ship-building program to 37,981. A large carrier has installed in it 101 complete equipments. A small motor torpedo-boat has seven. Certain of the smaller types of landing craft have as many as 13 complete equipments; others have as few as three. It is estimated that since December 7, 1941, some 300,000 complete equipments, each comprising two to 15 major units of equipment, have been installed in these 38,000 vessels and landing craft."

Postwar Estimates

There are a number of approaches to the problem of estimating the postwar demands for electron tubes. O[ne] interesting

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method is to consider as a basis the best prewar year. This is unquestionably the year 1937. During that year of good business, there was a big volume of sales resulting from the more than five years of depression-deferred buying. That this was a good year for American business in general is well established by the business indices. That it was a good year for electrical manufacturers in general and tube manufacturers in particular is borne out by the figures in the following table, showing the common stock per share earnings of a number of leading producers in the field:

	1935	1937	1939
General Electric	$0.97	2.21	1.43
Hygrade Sylvania	3.31	3.58	3.52
KenRad	1.49	2.31	(d) 0.25
Raytheon	(d) 0.15	0.46	(d) 0.48
RCA	(d) 0.03	0.42	0.35
Westinghouse	4.50	7.66	5.24

(d)—*deficit.*

It is very apparent from the above that 1937 was a peak year in comparison with either 1935 or 1939. The year 1937 is also a good one to study because the U. S. Department of Commerce Biennial Census of Manufactures covers 1937 as well as 1935 and 1939. The following table, using figures from the census reports, shows for these three years the dollar volume of electron tubes at the manufacturers' selling price:

	1935	1937	1939
Receiving	$28,975,216	$39,250,558	$32,946,740
Transmitting	1,874,456	3,004,569	2,267,856
Trans. Rect.	712,472	542,099	360,674
Phototubes	1,004,799	190,043	170,110
Industrial		935,109	2,317,080
	$32,566,945	$43,922,378	$38,062,460

Note: *The 1939 figures for industrial tubes are believed to include tubes for therapeutic high-frequency equipments which were included with transmitting tubes in 1935 and 1937.*

As noted above, the dollar figures given in this article are, as defined in the U. S. census reports, "selling values at factory or plant." For merchandised tubes, therefore, there is a large spread between this figure and list price. On the other hand, for small lots of industrial tubes sold direct, the figures may be the same as list price.

A certain amount of estimating and rearrangement of figures is necessary in comparing these years because the classifications covering the period are not uniform. Another factor, often neglected, which leads to an over-optimistic picture of the volume of tube business, is the ratio between the cost of the tubes in a complete piece of electronic equipment and the total cost of the equipment. For transmitters and receivers the census report for 1937 indicates a ratio of about 15 percent. In the case of industrial and most other types of equipment using tubes, the percentage is even lower. Therefore, the total business in electronic equipment may well be nearly ten times the tube business.

Using the 1937 figures as a basis, let us study each of the fields in which tubes were used in an attempt to gage the tube business in the immediate postwar years and also to make estimates for newly developed uses. Possible changes in cost and price levels cannot be taken into account, of course.

In any estimates on postwar business, it is necessary to define the time element as carefully as possible. The estimates that follow are based on the probable amount of available business per year for the first two or three years after present large-scale war-need manufacture no longer exists. In applications employing receiving tubes, the new sockets that will add to the demand for tubes can be created in a few months. The same is true of tubes used by amateurs and experimenters. On the other hand, the largest sizes of sealed ignitrons are used with power conversion equipments that require a year or more to engineer, build and install. In this latter category also come new applications like ultra-high-frequency relaying, where much research and experimental work must be done, plus accumulation of some actual operating experience, before large-scale manufacture gets underway. Therefore, in some cases, factors like those mentioned above may indicate a relatively low average level for the first three years, even though longer-term prospects are encouraging.

Another factor that must be kept in mind in studying the probable postwar electron-tube business is an increase in the number of producers. This is referred to later in connection with certain of the classifications. Also, in the case of most of the prewar manufactur the field the facilities availa tube manufacture have of ne been enormously increased 1937.

Receiving Tubes

The census reports sho number of receiving tubes pr as follows:

1935	78,231,1
1937	112,218,1
1939	109,520,8

In 1937 practically all the ing tubes made in this countr from ten manufacturers.

The War Production Bo cently released figures givi 1944 receiving tube requirem 144,000,000 and the 1945 r ments to be met as 180,0 units. Practically all of th production came from eight facturers. It is very eviden the huge, many-fold wartim pansion in the electron-tub ness was mostly in types not receiving tube classification.

The postwar readjustment lem is least serious in the c receiving tubes. There is rea hope that present unit volume be pretty well maintained. $63,000,000 receiving tube bu is a good probability. This is on an assumption of 35 cen tube, which is arrived at fro census statistics. Television f-m broadcasting for the firs years can be expected to add about 10 percent to this figure cluding picture tubes). This an estimated total of $69,00 in round figures.

Another factor that mus taken into account in conn with the postwar receiving business is the continued t toward organizational set-up corporating both receiver and ceiving tube manufacture. T the business available to conc making only receiving tubes t be relatively smaller than pre Obviously, more receiver manu turers may decide to make th own receiving tubes.

The number of receiving tu purchased by such users as a teurs, the Government, communi tion companies and the emerge service, although amounting to p sibly several hundred thousa tubes a year, is hardly a factor

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rison with many millions used adcast reception.

Transmitting Tubes

smitting Tubes for Televi- d A-M and F-M Broadcast- t is in radio transmitting that the enormous war ex- in tube manufacture has place. In 1937 ten manufac- made practically all the itting tubes used. Today this is just about double.

chief factor that has swelled al for World War II is the rge number of special and signs of high-cost tube types itary applications. For these the usual ratios of dollars- watt-output per-year-of-op- are much higher than the figure. In some cases the obtained can support the ost in commercial applica- but in many others it will be itive.

C reports indicate that on y 1, 1937, there were 685 sting stations and this fig- increased to 721 at the end year. Thus the average in ion during 1937 may be con- as 700 for a round figure. bruary of 1945, there were -m broadcasting stations in ion. In addition, as regards the situation at the opening e year 1945 was:

operating
under construction or soon to be constructed
applications on file with the FCC

is gives a total of 406 stations may be in operation during rly postwar years.

regards television transmit- there are nine now in opera- and 108 applications on file the FCC, making a total of 117 bilities for the early postwar . As each television station contains both an audio and transmitter, these may be dered as 234 transmitters for tion to the a-m and f-m units. for the early postwar years, e is the probability of 912 a-m, f-m and 234 television trans- ters or a total of 1552 transmit- This is slightly over double number of transmitters oper- g in 1937.

There are some factors tending to lower the tube maintenance cost in transmitters and some which increase it for the postwar period in comparison with the year 1937. It must be remembered, however, that less than half, or about $1,700,000 of the 1937 transmitting tube total went to broadcast transmitters. The remainder was sold for use by the government, amateurs and communication transmitters as well as other classifications. Therefore, a doubling of volume, say to $3,400,000, seems a reasonable postwar estimate.

Government Radio and Radar—Although it is doubtful whether the government will purchase very large quantities of transmitting tubes in the immediate postwar era, there will undoubtedly be a great deal of developmental activity and the building of a limited number of trial equipments for a wide variety of applications. It must be kept in mind, however, that there are enormous stocks of standardized tubes now being accumulated.

In 1937 the government business in radio transmitting tubes was probably about $500,000. Doubling this figure, on the basis that radar has been added, and then trebling it for increased activity, a $3,000,000 business in this field (excluding development) would seem to be an ample estimate. It must be remembered that in 1937 the sale of such tubes was included in the totals given for transmitting tubes.

Power Tubes for Transoceanic, Marine and Other Toll Radio Communication—Tubes for this use were included in the 1937 total. To a considerable extent, the companies using such tubes either manufacture them directly or through subsidiary companies, and therefore such business can hardly be considered as generally available. A total figure of $250,000 per year would certainly cover the field. Surplus government stocks might well supply much of this demand for several years.

Aids to Marine and Aircraft Navigation—This is almost wholly a new field since 1937. Developments in radar will undoubtedly provide numerous applications. However, unlike the war applications of radar, peacetime applications would appear to be very largely for short distances and of low power, indicating that the great majority of tubes will be small transmitting types. Assuming 1000 commercial aircraft and 6000 U. S. merchant vessels, an estimate of $700,000 would appear to be ample for this field.

Aviation Communication—Here the great question is the number of personally owned and operated planes that will be in use, plus an added estimate as to what proportion of these will have radio communication. The CAA has estimated 210,700 such planes after the war[3]. Other estimates have differed widely and mostly downward from this figure. If such communication units do come into use to anything like the extent indicated by the CAA estimate, then a whole new communication system, including ground stations, will have to be set up. In general the great majority of such equipments would be low power, including those on the ground and, therefore, the transmitting tube cost per unit would be rather low. In view of the time required to build up this business, a tube volume estimate of $1,000,000 per year for this field for the early postwar years would appear to be ample. This would include tubes for the transmitters of commercial airline planes and their base stations.

Mobile and Emergency Use—Included under this heading are not only some well-established applications but also recently enlarged or suggested services such as those used by:

Railroads and car ferries
Fire departments
Forest and conservation agencies
Public utility companies
Bus, truck and taxicab fleets
Highway departments
Special commercial operations, such as lumbering, quarrying and large-scale outdoor construction

In such applications as municipal and state police, probably the field is 50 percent to 75 percent saturated. On the other hand, the use of radio in connection with the dispatching of taxicabs, of which there are approximately 48,000 in the U. S., is practically untouched. It is to be remembered that for such equipment relatively small transmitting tubes are employed. ...tainly a $750,000 annual bu...

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an ample estimate for this classification.

Radio Relay Equipment—This is another new application and it is impossible to predict the rapidity with which it will grow or the extent to which it will grow. Again, however, the transmitting tubes used are of the low-power variety selling for $5 to $20 each. A total of $500,000 a year is certainly optimistic for this classification.

High-Frequency Induction and Dielectric Heating—Tubes for such service are included in the classification of transmitting tubes because they are so similar in their general ratings and sizes. If high-frequency heating is to be commercially successful and is to attain any large volume it is absolutely necessary that the tubes have a very long operating life. Replacements, considering a three-year life and an average of two tubes per equipment, would be approximately 700 tubes per year per 1000 equipments. Let's assume that in addition about 300 tubes would be used for installation in new equipment, making a total of approximately 1000 tubes per year. This represents a production of approximately four tubes per working day and, assuming an average figure of $100 per tube, there results a business of $400 a day. In this estimate the five-day working week has been assumed and, taking holidays into account, this means about 250 working days per year. This would represent a business of approximately $100,000 a year per 1000 equipments in use, plus the 300 tubes estimated as the initial complement in new equipments. It would certainly be an optimistic estimate to triple these figures, giving a total of $300,000 a year in tube business. Of course, it is possible that some new development in this field might result in a demand for a very large number of small units, but in this case the tube cost per unit might be only one-tenth that given above. In this classification, government surplus stocks may also be a factor.

Medical Field (Excluding X-Ray)—In this classification there are included only tubes of the radio transmitting type used to supply high-frequency output for such applications as heat therapy, cautery and electro-surgery. During the years 1935 to 1940, many hastily designed and none-too-well-built equipments were sold to doctors, hospitals, health institutes and gymnasiums. Today, probably more of these early equipments have been scrapped or are standing idle than are being used.

This business now is on a much firmer foundation as regards both its usefulness and design fundamentals, but it may be many years before the yearly business in tubes for this field gets back to the dollar volume of the best of the boom years. This broad field, however, still continues to show promising medical results and does constitute a worthwhile tube business. However, the more rational viewpoint now taken of its applications means that it is not going to require a huge supply of tubes. It would certainly seem that an estimate of $500,000 per year is ample.

Diagnostic equipment, such as the electrocardiograph, electronic stethoscope and the electroencephalograph, is going to be important and may well represent a rather large total of equipment business, but the tubes used are of the receiving type and their dollar volume is included in that classification.

Amateurs and Experimental—For 1939, sales of all transmitting tubes under the 50-watt rating totaled $272,128 and rectifier tubes under the 10-kv rating totaled $178,837. For 1937, the nearest comparable classification included tubes ranging from 5 to 250 watts in size and the total value was $1,520,256. The figures for rectifier tubes are even less informative in this field. On the basis that half the 1939 output noted above went to amateurs, plus an equal dollar volume of tubes in other classes, and that 1937 was a good year and 50 percent higher than 1939, the total reaches $700,000 as a rounded topside figure which would appear to be a satisfactory postwar figure to use.

Tubes of the So-Called Industrial Type

In 1937, there were five tube manufacturers that built the great majority of industrial tubes. In 1944, there were at least 12 comparable tube producers in the field.

Thyratrons—Such tubes, particularly in the smaller sizes below the rating of ½ ampere, will be used in relatively large quantities in industrial applications. The life will have to be long for acceptance and probably for a number of years to come the new-equipment market for tubes will far exceed the replacement market. This business amounted to about $350,000 in 1937, but it might well reach a yearly total of $1,500,000 in the early postwar period.

Sealed Ignitrons for Industrial Control—This field has expanded tremendously in the past five years and many of the tubes and items of equipment now used for war can be converted to peacetime production. A total of $750,000 per year would appear to be an optimistic estimate.

Ignitrons for Power Conversion—Here the picture can be likened to a certain extent to high-frequency heating in that a very long tube life is required. By the end of the war, there may be something like 2400 sockets in service. On the basis of a three-year life, this represents a renewal figure of approximately 800 per year, which corresponds to a requirement of about three tubes per working day. This field, particularly in the higher power sizes, is much nearer a saturation point than is the case for high-frequency heating. Let's assume that five tubes per day, or 1250 tubes per year, would take care of the demand, including new installations. At an average figure of $200 per tube, this represents a business of $250,000 per year.

High-Voltage Rectifiers

High-voltage kenotron rectifiers are used for such applications as dust precipitation, cable testing, paint spraying and paint de-tearing. This business amounted to only about $10,000 in 1937. Certainly an estimate of $50,000 is ample for a postwar year. There is always a possibility, of course, that some new application in the chemical or petroleum industry will create a large demand for tubes of this type but how soon such a demand would build up and the number involved cannot be subject to any real estimating.

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Photoelectric Tubes

t prewar year for photo-
bes was 1937, with a to-
es of $190,000. There is
believe that this will
crease and, therefore, an
of $250,000 does not seem
istic.
, there were four active
rers; today there are at

Cathode-Ray Tubes

o chief uses for cathode-
are in oscilloscopes and
d of television. It seems
obable that for at least
rs to come television re-
ill be sold under an aver-
of $150. U. S. census fig-
ated sales of 5654 radio-
h combinations costing
in 1939, which for these
a better year than 1937.
, a television receiver
purchaser more potential
ment. In general, how-
number of individuals in
-served areas who will
equipment of this sort at
f several hundred dollars
ly limited. Assuming a
50,000 cathode-ray tubes
sion receivers and 20,000
ment use, or a total of
d a figure of $15 each, we
l of around $1,100,000.
7, there were only two
rers who made these
quantity. Today there are
en.

Miscellaneous

llaneous applications in-
ch items as battery-charg-
es, regulator tubes, indi-
ubes, tubes for ionization
ballast tubes, automatic
ntrol tubes and many others
relatively small quantities.
of $1,000,000 would be a
imate for this group. (Tele-
repeater tubes and x-ray
re not included in the scope
article.)
r this general heading of
aneous, one might well ask
the many tens of thousands
um tubes that are going to
in the myriad of ingenious
that have been described
the past few years. The answer appears to be that while it is true that there will be tens of thousands and maybe hundreds of thousands of these applications, well over 99 percent of them will use only standard receiving-type tubes and the number so used is very small in comparison with those sold for use in home radio receivers.

The Export Field

The census figures for the prewar years included tubes exported. The question arises, therefore, to what extent the percentage of tubes manufactured during the early postwar years for export will exceed the prewar percentage figure. There are high hopes that this percentage will increase markedly. To offset this, however, it is probable that the war surplus stocks of tubes will be found particularly suited for use in this field.

The Time Element

In any series of estimates, such as in this article, one of the biggest uncertainties is the time element. Certain uses will develop more quickly than others. We have attempted here to arrive at some figure applicable to an early postwar year.

The total output of vacuum tubes in the U. S. over a period of prewar years has shown a fairly steady growth and there is no reason to believe that this normal growth has approached saturation or even that it has reached its maximum rate of growth. The whole question is: To what level will the business drop before resuming its steady growth after the war demand has been terminated?

In emphasizing the importance as well as the uncertainty of the time element, the following quotation from an address by Willard Chevalier of the McGraw-Hill Publishing Company seems most apt:[3]

> "The very mention of the word 'electronics' lays open a vast field for speculation as to its particular part in the broader program for technology in the postwar world. Unfortunately crystal gazing has its disadvantages. The prophet who looks into his globe and sees electronics doing most of the work of the home and the factory of the future should have another crystal ball handy into which he could peer and determine the date upon which these developments will be available to the customers."

Recapitulation

The following table brings together what may be termed optimistic figures given in the preceding paragraphs:

Receiving Tubes	$80,000,000
Transmitting Tubes	
Television, F-M and A-M Broad.	3,400,000
Government Radio and Radar.	3,000,000
Transoceanic, Marine, Toll.	250,000
Aids to Navigation.	700,000
Aviation Communication.	1,000,000
Mobile and Emergency.	750,000
Radio Relay.	500,000
High-Frequency Heating.	300,000
Medical Field.	500,000
Amateur and Experimental.	700,000
Industrial Tubes	
Thyratrons.	1,500,000
Ignitrons for Control.	750,000
Ignitrons for Power Conversion.	250,000
High-Voltage Rectifiers.	50,000
Photoelectric Tubes.	250,000
Cathode-Ray Tubes.	1,100,000
Miscellaneous.	1,000,000
	$85,000,000

No figures have been released on the total production of electron tubes in the United States during the past few years. However, the WPB has released figures on total production of military items of communication and electronic equipment for 1940 to 1944, inclusive. For 1943 and 1944, the yearly average was $3,000,000,000 or over. On the basis that 10 percent to 15 percent of this volume represented tubes (including, of course, the high ratio of wartime spares) this would give a total tube production approaching $400,000,000.

EDITOR'S NOTE: *Since this paper was written, the WPB has released figures on electron-tube production for 1944. It shows a grand total of approximately $406,000,000, which is close to the author's estimate.*

If receiving tubes are subtracted from this total, there would remain at least $300,000,000 for all types as compared with the $16,000,000 volume estimate for a postwar year. This may seem like a tremendous decline but if compared with the corresponding figure of a little under $5,000,000 for 1937 it represents a pretty healthy rate of growth.

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(3) Chevalier, Willard, Technolog[illegible] Postwar Expansion, *Electrical Engine[illegible]* p. 47, Feb. 1945.

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Wire Splice Detecto

Steel wire is magnetized by passing it between the poles of two magnets. The m poles created at discontinuities trigger an electronic circuit when the wire is through a detector coil. Aural and visual indications are given

By F. S. HIRD
Bell Telephone Laboratories
New York, N. Y.

THE SPLICE DETECTOR to be described utilizes magnetic poles created at splices in steel wire to operate an audible and visual alarm.

The wire under test is magnetized longitudinally by passing it through a strong magnetic field. It is then passed through a detector coil in which voltages are generated by the motion of the magnetic poles produced at the discontinuities. The voltage thus generated is amplified and impressed upon a thyratron trigger tube which operates a buzzer, giving an audible signal. The buzzer is also connected to a telephone receiver, which allows the signal to be heard in noisy locations. A visual signal is provided by a cathode-ray tube.

The sensitivity of the apparatus is such that it is possible to detect a single-strand splice in paired wire containing a total of 14 steel strands.

General Description

The apparatus which makes up the splice detector is shown in Fig. 1. The magnet assembly, through which the wire is passed first, is shown on the right of the photograph. The coil which responds to magnetic discontinuities in the wire is shown at the left.

The detector apparatus is shown in the center of the photograph. Connection to the 115-v 50-60 cycle a-c supply is made at the left end of the box. The telephone set is plugged in on the right side. The detector coil is connected at the right rear. The control on the left of the front panel is the power switch. Next to it is a switch used for restoring the circuit to normal after the gas tube is triggered. The indicator tube is mounted so that it is visible through the circular window at the center of the panel. The sensitivity control for the detector is at the extreme right on the front panel. This control, designed for screw-driver operation to prevent accidental changes in adjustment, determines the triggering point of the gas tube. The screwdriver control next to the sensitivity control is used to adjust the shadow angle of the indicator tube.

Field wire may now be laid from an airplane by means of apparatus such as this, shown being installed in an Army C-47. The splice detector is particularly valuable in checking such wire, since discontinuities are frequently masked by insulation

The magnet assembly consists of two horseshoe magnets having very high field strength. They are held against a square brass bar, with the two north poles facing each other. The wire passes through a ⅛-in. longitudinal hole in ... The small size of the hol... uniform magnetization of ... Its length prevents sidewis... near the magnetic poles.

The detector coil consist... turns of wire wound on a ... spool, having a ⅛-in. hol... core for passage of the wi... minimum dimension of the ... such that the turns can be ... in close proximity to the wir... passes through. The coil i... sufficiently long to prevent ... being generated due to whip... the wire. The coil moun... made of wood.

Circuit Details

A schematic diagram of ... tector circuit is shown in F...

Volatges due to irregular... the wire, generated in the ... coil, are fed into a two-sta... age amplifier utilizing tub... and VT_2. The amplifier out... erates a thyratron trigge... VT_3, which operates a ... through a relay.

The circuit constants of t... plifier were selected to obtai... mum gain consistent with go... formance at the frequencie... mally encountered, and to ... the need of screen bypass ... tors. Excellent stability is ac... Filtering is employed in the ... circuits of each stage to att... high-frequency voltages pic... in the coil. It has been foun... minute magnetic irregularit... the wire cause such high-fre... voltages to be generated, and ... voltages might trigger the ... tron were it not for the ... filters.

The normal frequency of a ... pulse generated at wire spli... 10 to 30 cps, depending upo...

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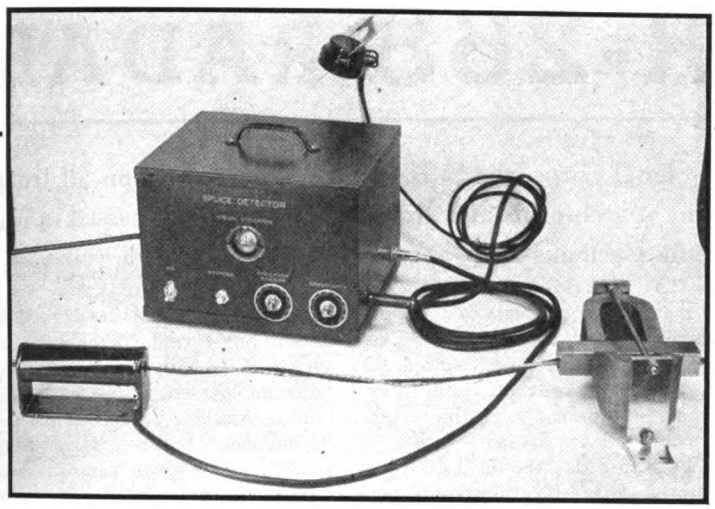
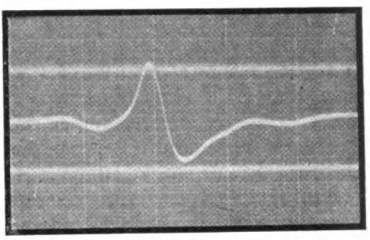


FIG. 1—The equipment, complete with built-in power supply. The magnetizer is at the right, the detector coil at the left and the amplifier-trigger-indicator unit at the center. Single-strand splices in paired wire containing a total of 14 steel strands are readily located



Oscillogram showing the nature of the amplified pulse produced when a lapped splice passes through the detector coil

speed of the wire as it travels through the coil.

The thyratron detector is a gas tube. The plate-circuit d-c relay operates on 10 milliamperes. Resistor R_1 is placed in series with the relay winding to restrict the plate current of the thyratron to the limits of the relay winding, the tube and the power supply. There is also a normally-closed switch *SW* in the plate circuit, the operation of which will restore the trigger circuit after the tube has operated. The sensitivity control P_1, in the trigger tube input circuit, permits the bias on the grid to be varied through a range of 0 to 12-volts negative, for close adjustment of trigger action.

A visual signal is obtained through the use of the indicator tube VT_4, which is connected to the output of the amplifier in parallel with the trigger tube. The shadow angle, which varies to indicate voltage changes, has a sensitivity adjustment from 0 to 20-volts negative, through P_2.

Transformer T has a center-tapped high-voltage secondary rated at 650 volts, 40 milliamperes. Two gaseous type regulator tubes VT_6 and VT_7 are connected in series across the output of the rectifier tube VT_5, and maintain a substantially constant potential of 210 volts. The filtering resistors R_3, R_4 were selected so that the current through the regulator tubes, with the plate circuits to the test set disconnected, was approximately 30 milliamperes. It is essential that the voltage regulators be operated near their maximum rated current with minimum load current on the set.

Operation

When using the splice detector, it is essential that the magnet be placed in line with the coil and separated from it by approximately three feet, in order to prevent stray magnetic fields from influencing the coil. It is also necessary to polarize the magnet and the coil properly. The magnets and the coil should be so related that the initial voltage generated in the coil will impress a positive voltage on the grid of the trigger tube, thereby reducing the negative bias on the grid and causing it to fire. The time constants of the circuit are such that if the negative half-cycle of the voltage is impressed first, the full effect of the succeeding positive half-cycle is not realized and the circuit is less sensitive and unreliable in operation.

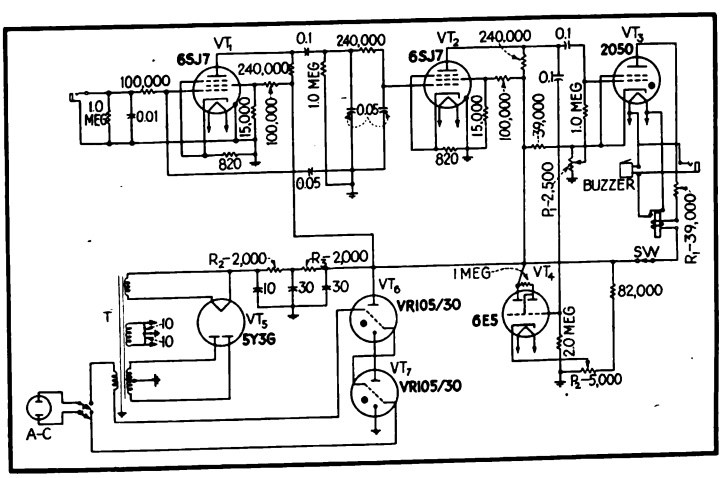


FIG. 2—Circuit of the splice detector

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The SCR-268 RADAR

Developed before the war by the Signal Corps, the SCR-268 has seen service on all fronts detecting enemy aircraft, directing searchlights and guns toward them. Surpassed in performance, and captured by the Germans and Japanese, it may now be described

ON THE EVENING of May 26, 1937, Mr. Harry Woodring, the Secretary of War, stood with a group of officers and civilian scientists on a field of the Signal Corps Laboratories at Fort Monmouth, New Jersey. Before them, spread over the field, were the transmitter and receivers of a radio detector, the SCR-268 prototype. Connected with the radar were the controls of a standard anti-aircraft searchlight.

As prearranged, an Army aircraft flew over the field in the darkness. Three enlisted men, viewing oscilloscopes, put the radar "on target" and tracked it across the sky. When tracking was established, the command was given to light the searchlight. As the light pierced the darkness, the aircraft, caught in the beam, became visible to those on the ground.

The next day, orders were given to move the equipment to a remote corner of Fort Hancock, where secrecy could be better preserved. In the eight years that have intervened, secrecy has been the watchword of radar development. But in November 1944, the SCR-268 was reduced in classification from "confidential" to "restricted". By that time, the equipment had been captured, with crews and instruction books, by the Germans and the Japanese. Moreover it had been far surpassed by later radar equipments. While still in use, the 268 was obsolescent, almost antique.

When the editors of ELECTRONICS first approached Signal Corps authorities for permission to describe the SCR-268, they were asked "Why do you want to describe that set?" The answer, not obvious to those working in the radar field, is that the greater part of the electronics industry has never seen a radar set, or a technical description of one, in any form. The SCR-268, by virtue of its early development and wide employment in the war, is not only a significant milepost in radar development, but the first radar to reach such a venerable position that describing it would offer no aid or comfort to the enemy.

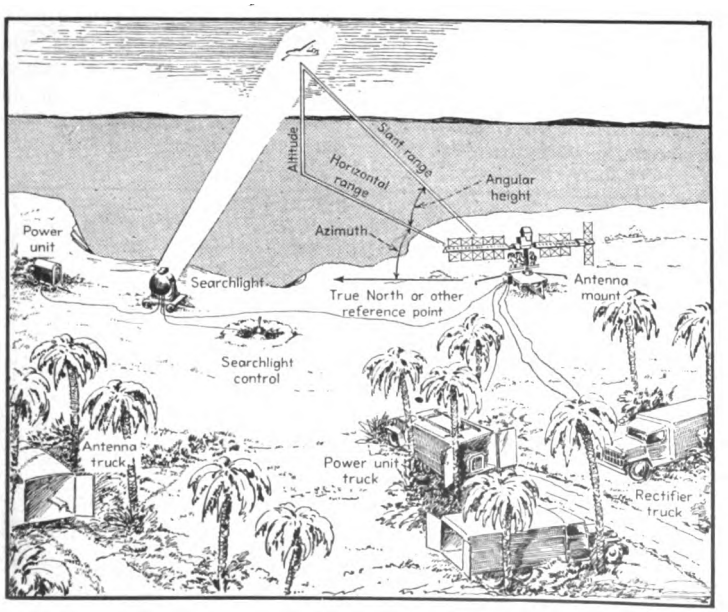

FIG. 1—Artist's sketch illustrating a typical setup, including power supply and transporting trucks

Basic Elements

A radar detects the presence and position of objects by means of reflected radio waves. In the case of the SCR-268, the "object" is ordinarily an aircraft, and the radio waves are projected in sharp bursts or "pulses" at a rate of 4098 per second. A pulse is transmitted every 244 microseconds. Each pulse is of extremely short duration, approximately six microseconds. Between pulses, there is a period of about 240 microseconds during which the radar receivers may detect the echoes reflected from the target aircraft.

When the radar detects a target, the position of the aircraft is indicated in three coordinates, known as the slant range, the elevation (or angular height), and the azimuth. The slant range is the distance from the radar to the target. The elevation is the vertical angle subtended at the radar by the target and the ground plane. The azimuth is the horizontal angle subtended at the radar by the target and true north. The target coordinates are illustrated in Fig. 1.

The radar measures the range of the target by timing the interval between transmission of a pulse and reception of the echo. Since radio waves travel at a velocity of 0.186 miles per microsecond, for each microsecond in the interval the wave travels 0.186 miles round trip from radar to target and back. Accordingly, the distance to the target is 0.093 miles for each microsecond

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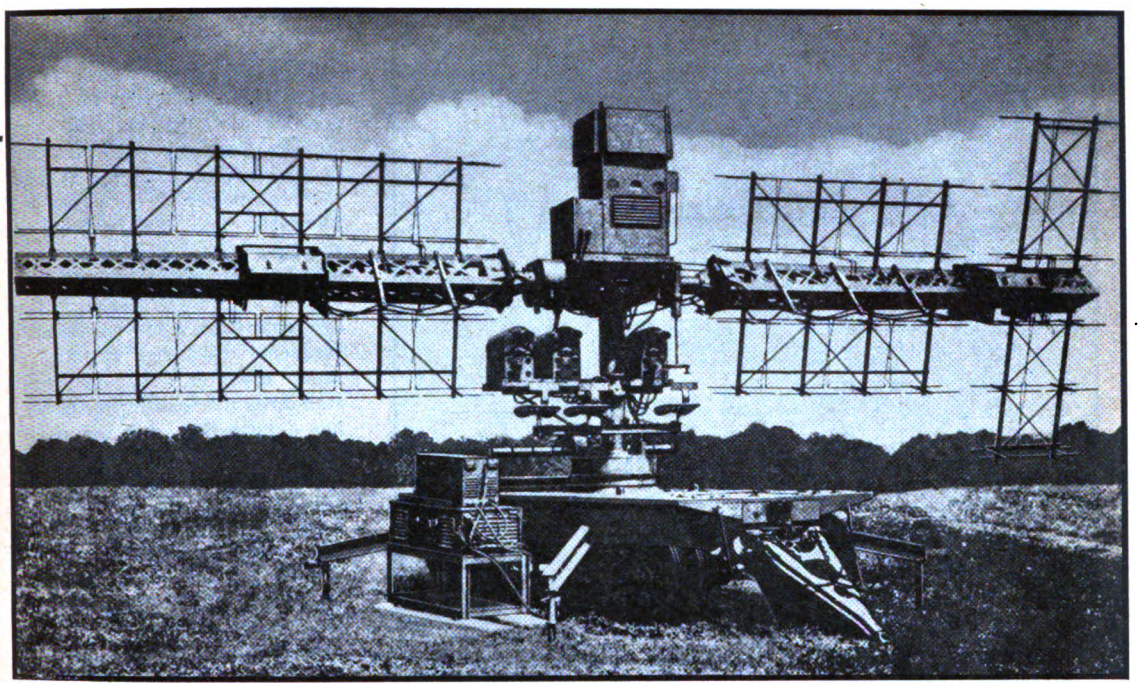

FIG. 2—The SCR-268 radar, seen from the back or control position, showing the azimuth receiving array at the left, the elevation receiving array at the right and the transmitting array in the center

in the interval. If the measured interval between transmission and reception is 100 microseconds, the range of the target is 9.3 miles. The maximum interval which can be accommodated is the interval between pulses, or about 240 microseconds. Consequently, the maximum detection distance, as determined by the pulse interval, is 0.093 x 240 = 22 miles. Sufficient power in the transmitter and sensitivity in the receivers are provided to produce a discernible echo from an aircraft at this distance.

The azimuth and elevation angles are measured by noting the angles at which the receiving arrays are pointed with respect to true north and the ground plane as the target is observed. In the SCR-268 two directive receiving aerials are provided, the azimuth and elevation arrays. The reception pattern of the azimuth array is a fan-shaped figure with a long vertical axis. The pattern of the elevation array is similar, but rotated through 90 degrees, that is, the long axis is horizontal.

The target information gathered

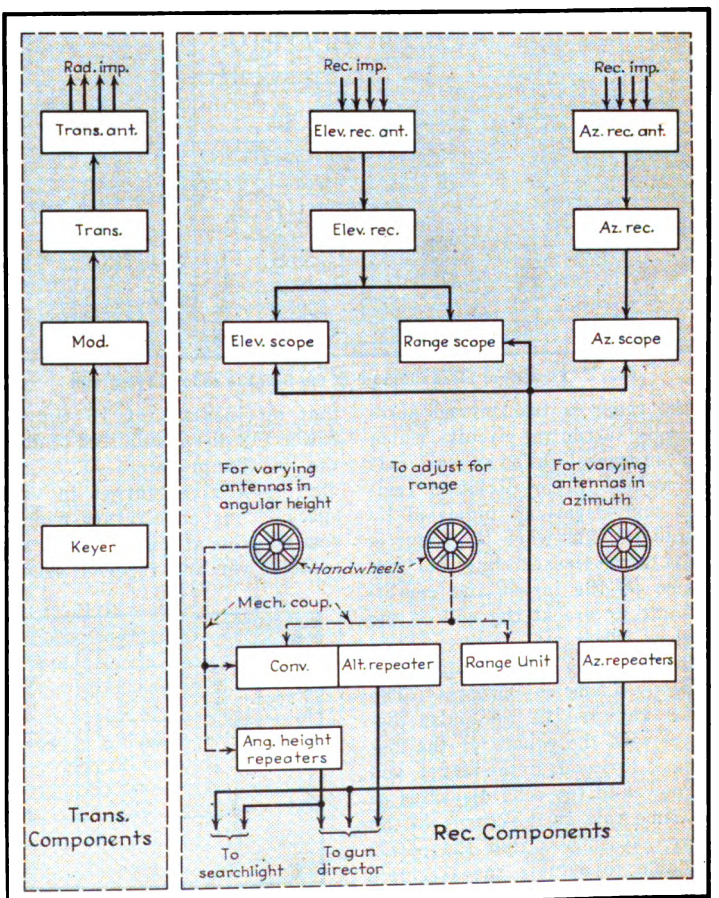

FIG. 3—Simplified block diagram showing basic components of the equipment

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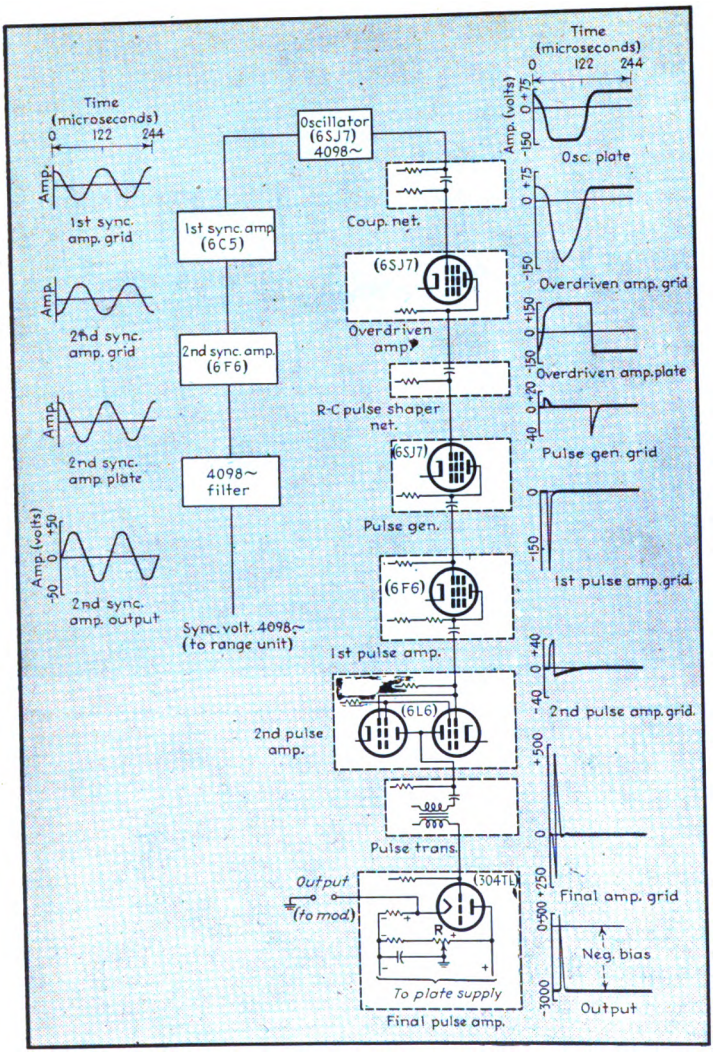

FIG. 4—Functional block diagram of the SCR-268 radar keying unit

by the radar is transmitted automatically to control circuits which keep the searchlight or anti-aircraft gun trained in the direction (azimuth and elevation) indicated by the radar. Thus when the radar is on the target the searchlight or gun is also on the target and can illuminate or fire at the will of the artillery officer.

The reflection of radar signals is a highly inefficient process.[1] The power radiated in the pulse disperses with the square of the distance as it travels to the target, and the power in the echo disperses at the same rate as it returns to the radar. It follows that the power available to actuate the receivers falls off as the fourth power of the distance to the target. This means that an increase of 16 times in power (12 db) is required to double the maximum range of a radar viewing a given target in empty space. Thus an aircraft which is easily visible at 5 miles, using moderate power and receiver sensitivity, may be completely invisible at 20 miles.

This reasoning points to the necessity of employing the highest possible power in the transmitter and the greatest possible sensitivity in the receiver. In the SCR-268, the peak power of the pulses is 75 kilowatts, and the receivers are sensitive to a signal power of 0.1 of a micromicrowatt (10^{-13} watt). Judged by pre-war standards, these are remarkable achievements at the frequency (205 mc) at which the radar operates. But by present standards the transmitter power is not outstanding, and the receiver performance is poor. Nevertheless, the power and sensitivity are adequate to detect aircraft at distances up to 22 miles, provided the aircraft is not too close to the horizon.

General Description

The SCR-268 is pictured in Fig. 2. The radar components are mounted on a trailer. In addition, four large trucks are required, one supplying primary power, another supplying high voltage for the transmitter, and two for the transportation of the radar components.

The trailer consists of a rotatable pedestal which carries three antenna arrays. From left to right as seen from the back of the equipment, these are the azimuth receiving array, the transmitter array, and the elevation receiving array. Behind each receiving array is the corresponding receiver. Atop the pedestal is the transmitter. Directly below the transmitter are three oscilloscopes, with bucket seats in front of them. Here the three operators observe the azimuth, elevation and range, turning handwheels which keep the radar pointed at the target. The handwheels are con-

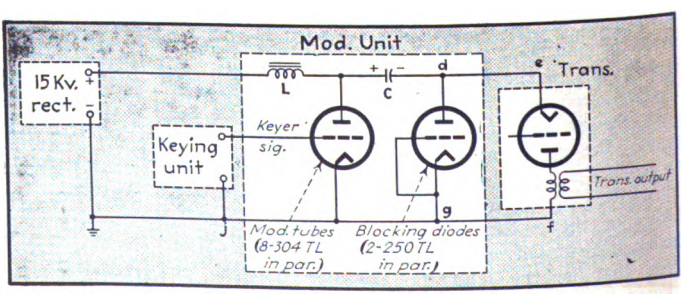

FIG. 5—Simplified schematic of the modulator, which produces wave forms shown in Fig. 6

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nected also to the converter which transmits the target coordinates to the associated searchlight control or gun director. On the ground beside the trailer are the keyer and modulator units which drive the transmitter.

The SCR-268 weighs 82,315 pounds, complete with all auxiliaries and trucks. It consumes 15 kva of power. Despite these large figures it can be (and has been) set up and ready for operation within a few hours of being put ashore at a beachhead.

The block diagram, Fig. 3, shows the flow of the signal through the equipment. At the left are the transmitter components, which comprise a separate group. The keyer establishes the basic timing of the transmitted pulses at 4098 per second and produces the short (3 to 9 microsecond) pulses which drive the modulator. The modulator raises the power level of the keyer output and applies modulating pulses to the transmitter. The transmitter is a self-excited tuned-plate tuned-grid oscillator consisting of 16 tubes in a ring circuit. The transmitter output is applied to the transmitting array, which radiates a beam of circular cross section approximately 10 degrees wide.

When the transmitted beam encounters a target, the echo is returned to the two receiving arrays. The directivity of these arrays is about 12 degrees in the azimuth array and 9 degrees in the elevation array. By means of receiving antenna "lobe switching", to be described later, the directivity in azimuth and elevation is refined to about ±1 degree in each coordinate.

The signal received by the elevation array is passed to the elevation receiver and thence to two cathode-ray indicators. One indicator displays the range of the target, the other the elevation. Both are "type A" indicators, that is, they are essentially similar to a conventional test oscilloscope. The cathode-ray beam is driven by a sweep circuit at constant speed from left to right. The echo signal from the associated receiver is applied to the vertical deflection plates so that the beam is deflected upward whenever an echo is received. At the left end of the oscilloscope trace the transmitted pulse appears. This establishes the "zero" of the time scale. The distance from the transmitted pulse to the echo, measured on the range indicator, gives the distance to the target, or range.

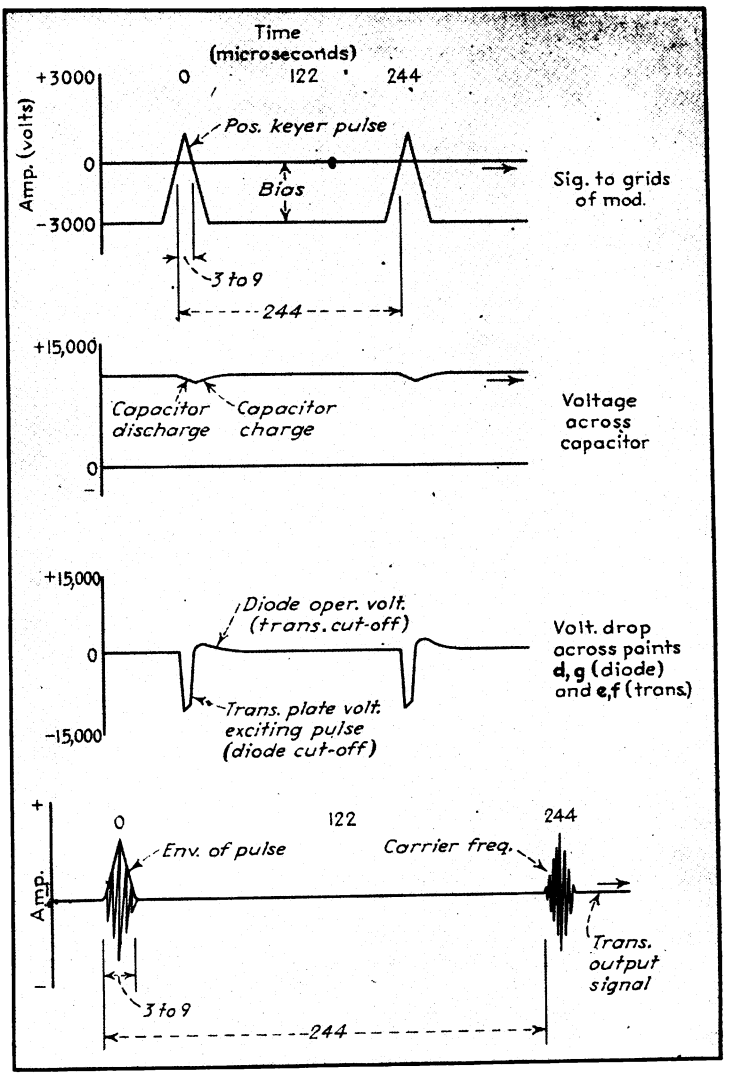

FIG. 6—Modulator wave forms, obtained by means of the circuit shown in Fig. 5

The elevation indicator is similar, except that two echoes are displayed, slightly displaced from one another. The two echoes, known as the "split image", are produced by shifting the directivity pattern of the elevation array slightly, at a rapid rate, by the receiving antenna lobe-switching method. The operator adjusts the elevation array until the two echoes in the split image have the same height. The array is then pointed directly at the target within the one-degree error previously mentioned.

The azimuth receiver is connected to a similar oscilloscope which displays a split image produced by shifting the pattern of the azimuth array. The operator at this indicator adjusts the orientation of the azimuth array until the two pulses in the split image are of equal height. The azimuth array is then pointed at the target within 1 degree accuracy.

The remaining items shown in Fig. 3 are the repeaters and converters which transmit the target information in suitable form to the searchlight or gun director. The principal electronic component here is the range unit, which introduces a time shift in the deflection circuits of the range indicator. When

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the operator turns the range handwheel, the radar echo is moved horizontally on the indicator screen. This permits the echo to be placed over a specific reference point, from which the range may be read accurately. The range accuracy of the SCR-268 is plus or minus 200 yards.

The high voltage power rectifier supply for the transmitter is mounted in a separate truck as previously mentioned. This latter rectifier has a capacity of 500 milliamperes at 15,000 volts. Since the output drain on this power supply is confined to periods less than nine microseconds long, with 240 microsecond intervals between them, the filter required is not large.

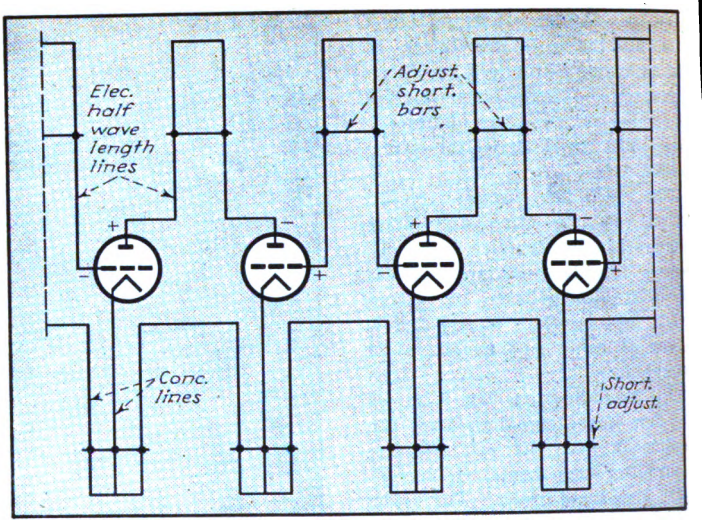

FIG. 7—Simplified schematic of the SCR-268 radar transmitter, showing just four of the sixteen type 100TS tubes used in a ring circuit

The Keying Unit

The heart of the radar is the keying unit, which establishes the basic timing of the system. The keyer must first establish the rate at which the pulses are sent out, 4098 per second. Secondly, it must produce individual pulses of the requisite short duration, and it must prevent any undue variation in the length of successive pulses.

The output of the keyer is used to drive the modulator tubes, which are cut off between pulses by a heavy negative bias. The keyer output is, therefore, a positive pulse capable of overcoming this negative bias and driving the modulator grids well into the positive region. These requirements add up to a formidable total. The keyer must provide an accurately timed pulse of from three to nine microseconds length, and of some 3500-volts peak amplitude. This requirement is met by the use of eleven tubes in the keyer unit, two of which are power supply rectifiers.

Figure 4 is a simplified schematic of the keyer unit. The basic timing element is the 4098-cps oscillator (6SJ7 at the top of the diagram). This is an electron-coupled oscillator of the Hartley type. Two outputs are taken from the oscillator, one intended for the range unit and the other for the keyer proper. The former path consists of two amplifiers and a 4098-cps filter, the output of which is a 4098-cps sinewave of 50 volts peak amplitude. The latter, or keyer, path starts at the oscillator plate, which provides a flattened (non-sinusoidal) wave. This voltage is passed through a coupling circuit (0.01 μf series capacitances, with 100,000-ohm and 50,000-ohm shunt resistance) which sharpens the oscillator output. The sharpened wave is then applied to an over-driven (grid-current limiting) amplifier which flattens the wave again, but by this time the pulse possesses a much sharper leading edge. Following is a peaking circuit of very short time constant (0.00005 μf and 50,000 ohms) which responds only to the leading and trailing edges of the applied wave. The output consists of a small short positive pulse, and a somewhat larger negative pulse which is not thereafter used. These pulses are applied to the pulse generator which is biased to cut-off. It responds to the small pulse, but not to the negative pulse. The output of this stage is a sharp pulse of about -170 volts amplitude.

The remaining portion of the keyer is occupied with increasing the peak voltage of this pulse and reversing its polarity. The first pulse amplifier (a 6F6 beam-power tube) is intended to produce a higher current pulse, without a high voltage output. This current pulse drives two 6L6 beam power tubes in parallel, the output of which is conducted to a pulse transformer, capable of passing very short pulses. The output of the transformer is a double-peaked wave of about 750-volts peak-to-peak amplitude, centered about a point two-thirds up from the negative peak. This wave is applied to the grid of the final amplifier, a 304TL triode. This tube is a high-current thoriated-tungsten triode, consisting of four triode units in a single envelope.

When the pulse arrives at the 304TL grid the tube passes a current of approximately 1 ampere through a cathode coupling resistance, thus producing a pulse of 3500 volts peak amplitude across the output terminals. Since the tube is biased to cut-off, there is no response to the negative peak. Between pulses, when the 304TL is not conducting, its output terminals are connected across the B-supply voltage. One output terminal is some 2500 volts negative (adjustable by resistor R) with respect to ground. This is the bias voltage for the succeeding modulator tubes. The use of the cathode-follower circuit in the final keyer amplifier provides a low impedance output, which permits conducting the short-length pulses over coaxial cables to the modulator unit.

The Modulator Unit

The function of the modulator unit is to amplify the keyer output to a high power level, suitable for

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plate-modulating the transmitter (r-f oscillator) proper. Figure 5 shows the simplified schematic.

The modulator tubes (8 type 304TL tubes in parallel) act as an electronic switch, under the control of the keyer. The electronic switch is in series with the storage capacitor *C*. This capacitor is charged continuously from the high voltage power supply (15,000 volts) through the choke *L* and the blocking diodes (2 type 250TL tubes in parallel). When a positive pulse is delivered by the keyer to the modulator grids, the modulator plates suddenly conduct. The inductor *L* impedes any flow from the power supply through the modulators for the duration of the pulse. Therefore, the only source of plate current is the storage capacitor *C*. This capacitor discharges, during the pulse, through the series circuit composed of the modulator tubes and the transmitter (oscillator) tubes. The resultant sudden pulse of current causes the transmitter to oscillate and it continues to do so while the pulse is applied.

The current passing through the modulator tubes is about 10 amperes, and the voltage drop across them is about 3000 volts. Hence 12,000 volts at 10 amperes passes through the plate circuit of the transmitter. This is a peak input of about 120 kilowatts, of which about 75 kw appears as useful r-f output power.

When the modulators conduct, they form a closed circuit of which the storage capacitance and the series inductance (leads and transmitter tank circuit) are a part.

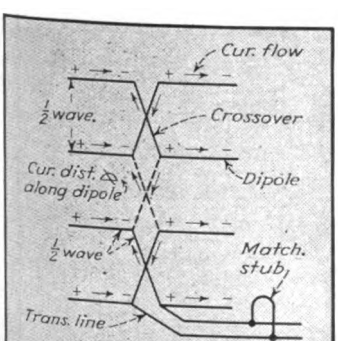

FIG. 8—Basic directive array scheme, showing eight of the sixteen transmitting dipole elements. The associated reflectors are omitted in this drawing

There is, therefore, a tendency of the current in this circuit to oscillate and over-shoot in the negative direction. This causes the transmitter to be cut-off sharply at the conclusion of the pulse. Any further oscillation in the modulator circuit is suppressed by the blocking diodes.

Modulator wave forms are shown in Fig. 6. It is to be noted that the pulse lasts only about 2.5 percent of the total time, so that only a small portion of the charge stored in capacitor *C* is withdrawn during each pulse. The diodes permit this charge to be replaced, at a slow rate, between pulses. But the diodes, being one-way conductors, have no effect during the pulse discharge.

The Transmitter Proper

The function of the transmitter is to develop r-f pulses of 75 kw peak power. The average power is not nearly so great, however, since the transmitter is turned on only 2.5 percent of the time (4098 pulses, each about 6 microseconds long, per second). The essential problem of the transmitter design, then, is providing sufficient emission in the transmitter tubes to meet the momentary high power requirements. The required peak emission, as indicated from the discussion of the modulator circuit, is of the order of 10 amperes. No suitable tube was available with such emission, so it was necessary to employ a large number of tubes. The tubes are type 100TS.

It was not feasible to connect the transmitting tubes in parallel or in push-pull-parallel because the addition of the tube capacitances would prohibit operation at the high frequency desired. To avoid this difficulty, the ring circuit was adopted. Essentially, this is a multiple push-pull tuned-grid tuned-plate arrangement. In this circuit, an elementary form of which is shown in Fig. 7, the tubes are separated by tuned circuits and arranged in a closed ring. As shown, grids of adjacent tubes assume opposite polarity, and to sustain oscillations the plate of each tube has the opposite polarity from its grid. When an even number of tubes is employed in the ring, the necessary alternation of grid and plate polarities between adjacent tubes is maintained throughout the ring. Since the tube capacitances are essentially in series, any required number of tubes may be employed. Sixteen tubes are required to provide the necessary emission.

The tuned circuits are segments of parallel transmission lines, approximately half-wavelength long, with adjustable shorting bars. The r-f current in all the shorting bars, at any instant of time, is in the same direction, so the shorting bars form a virtual closed circuit from which energy may be picked up by a pick-up coil. A single-turn pick-up coil is used to connect the transmitter to the output transmission line.

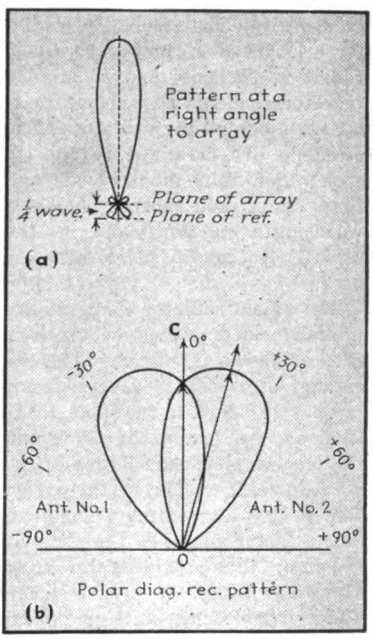

FIG. 9—(a) Directive pattern of receiving array with reflectors spaced ¼-wavelength apart. (b) Double receiving antenna pattern, obtained by lobe switching described in the text

The filament power for the transmitter tubes is conducted through quarter-wave concentric transmission lines, shorted at the input end. These segments prevent absorption of r-f power by the filament circuit.

The modulator is connected to the transmitter through a high-voltage slip ring which permits the pedestal to turn when following targets without breaking the connection. The transmitter plate circuits are joined at points below the shorting bars and connected to ground. The

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modulator output, in the form of a high-voltage negative pulse, is applied to the transmitter filaments. The transmitter grids are joined at points beyond the shorting bars and returned to the filaments through a resistance.

Transmission Line and Radiator

From the pick-up coil, the transmitter output is conducted over an open-wire transmission line to the transmitting radiator. The radiator consists of 16 half-wave dipole radiating elements and 16 similar reflector elements spaced one-quarter wave behind the radiators. The elements are arranged parallel to each other, four dipoles wide and four high, and spaced one-half wavelength in the plane of the array. Horizontal polarization is used.

The dipole radiator elements are interconnected cross-wise at their ends as shown in Fig. 8. Thus the current in each half-wave segment in the array flows in the same direction, at any instant of time, and there is complete cancellation of the r-f field in the plane of the array. The field is a maximum along an axis at right angles to the plane of the array, thus providing the necessary directivity of transmission. The transmitting antenna beam width is about 10 degrees wide between the 3-db points, that is, the field radiated five degrees off the axis is 3 db less than the field along the axis. The gain of this radiator, relative to an isotropic (point-source) radiator, is about 400 times. Thus the effective power radiated to the target is about 400 x 75 kw = 30,000 kw. A matching stub is used on the transmission line to match the impedance at the ends of the dipoles.

Receiving Arrays and Lobe Switching

The receiving arrays are very similar to the transmitting radiator, differing only in shape and in the provision of lobe switching. The azimuth array is six dipoles wide and four dipoles high, with a similar number of reflectors. The radiation pattern formed by this arrangement is a fan-shaped figure with its long dimension in the vertical plane, which permits discrimination in the azimuth (left-right) coordinate. The elevation array is arranged two dipoles wide and six dipoles high with corresponding reflectors. The radiation fan in this case has its long dimension in the horizontal direction, an arrangement suitable for discriminating in the elevation (up-down) coordinate.

Both receiving arrays are arranged for lobe switching to refine the accuracy of the angular indications. The technique is as follows: The directivity pattern of an array is a lobe-shaped figure like that shown in Fig. 9(a). Suppose, first, that two arrays are used side by side at a slight angle to one another. Then two overlapping lobes are provided. The signals received from the two arrays are of equal amplitude when the signal arrives from a direction midway between the two lobes as along line OC in Fig. 9(b). If the signal arrives from the left the signal from the left-hand lobe predominates, whereas a signal from the right causes maximum amplitude in the right-hand lobe. The sharp slope of the lobe patterns at their intersection makes the direction of equal amplitude correspondingly precise.

The technique of lobe-switching provides a double-lobe pattern from a single array. The array is divided into two halves (left and right halves in the azimuth array) which are connected not by cross-wires as in the transmitting arrangement but by phasing stubs, that is, adjustable segments of transmission line somewhat less than a half wavelength long. Two terminations are taken from the array, one at the left end, the other at the right end as shown in Fig. 10. The directivity of such an array, with phasing stubs inserted, is found to be slightly different, depending on which termination is used.

To illustrate this effect, consider

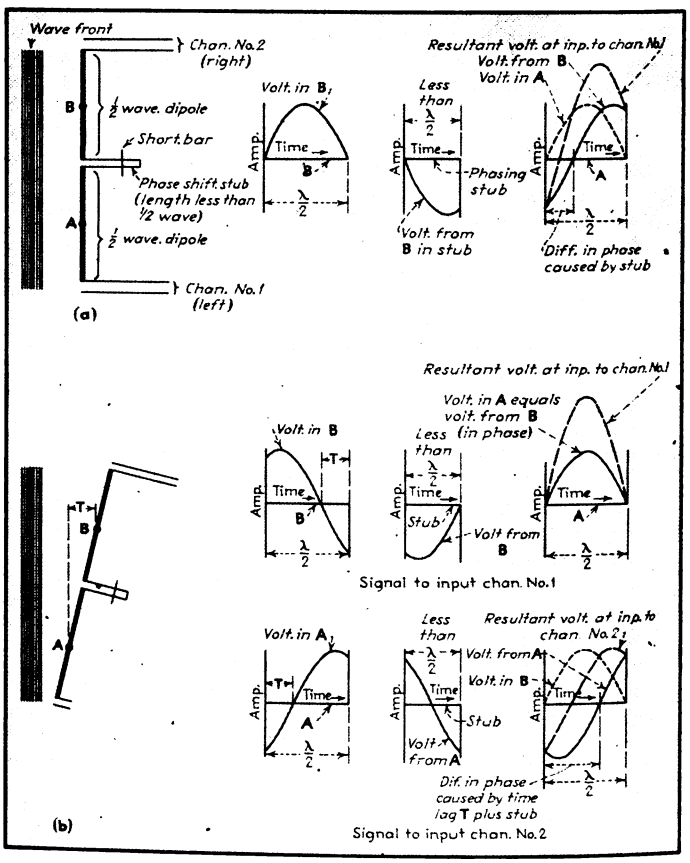

FIG. 10—SCR-268 radar receiving antenna lobe-switching results showing (a) voltage when the plane of the array is parallel to the wave front and (b) voltage when the plane of the array is at an angle to the wave front

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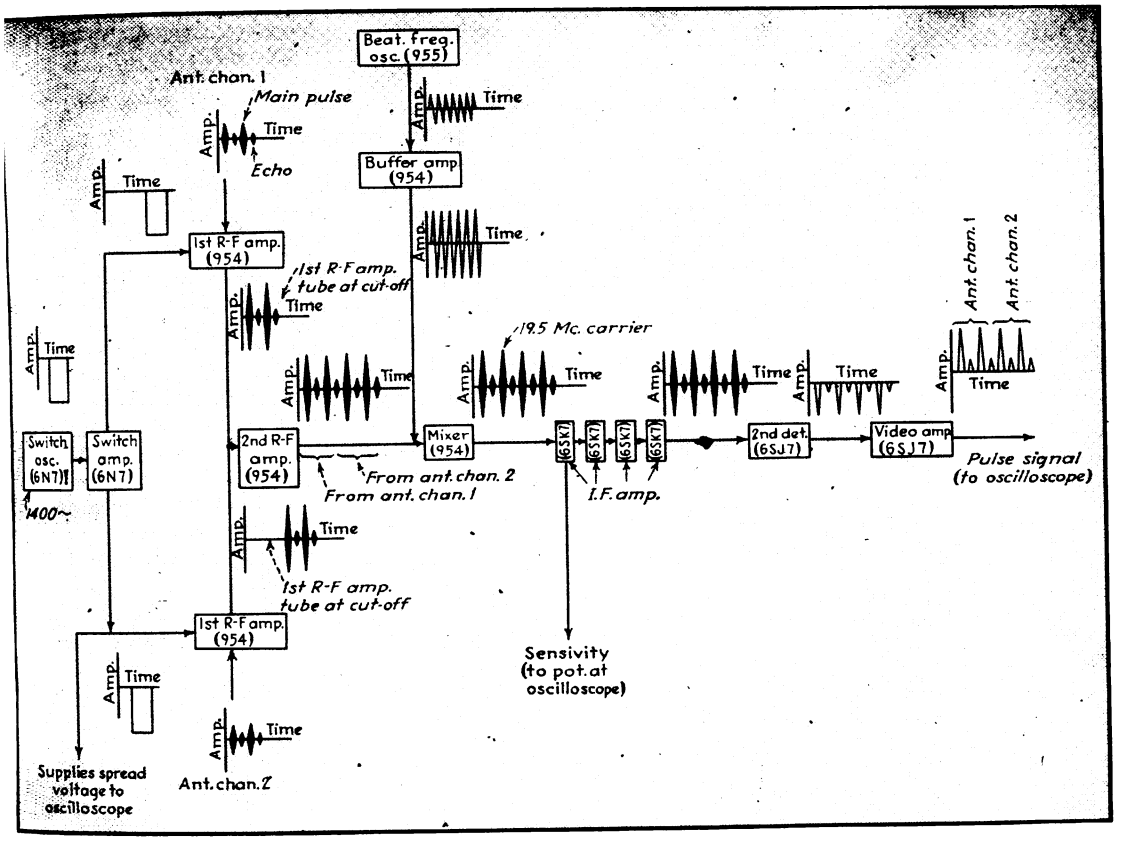

FIG. 11—Functional block diagram of one of the two receivers

a signal wave front arriving parallel to the array. The wavefront induces voltage in the two halves of the array at the same instant. Consider the array from the back and assume that the left-hand termination is in use. The signal induced in the left half of the array arrives at once at the termination, but the signal from the right half of the array arrives at the left-hand termination only after a delay caused by its passage through the phasing stub. Hence the net voltage arriving at the left-hand termination is a vector sum, and this vector sum is the same as though the wave had arrived from an angle to the left and as if no phasing stubs were present. The phasing stubs thus cause the antenna pattern to shift to the left when the left-hand termination is in use.

By the same process, the stubs cause the directivity of the array to shift to the right when the right hand termination is in use. By shifting alternately from left-hand to right-hand termination, the effect of two lobes is produced. Accurate direction finding is obtained when the signals from the two terminations have the same amplitude. In the elevation array, the array is divided into top and bottom halves and the same effect is produced in the elevation coordinate.

In practice, the phasing stubs are adjusted when receiving a wavefront of known orientation until the peaks of the lobes are spaced approximately 10 degrees and a symmetrical variation in signal is obtained on either side of the center direction. Thereafter this adjustment is preserved until the radar moves to a new location. A signal generator ("tweeter") produces the required wavefront and a technique has been developed to avoid the effects of external reflections. As in the case of the transmitting array, matching stubs are employed on the transmission lines to match the receiving array impedance to the line.

One possible source of trouble in the operation of the radar is the existence of side lobes, that is, minor directivity patterns offset from the main pattern by some 25 degrees. Proper adjustment of the array will keep the sensitivity of the array in these side directions about 30 db below that of the main lobe, but the effect cannot be eliminated entirely. Thus a nearby target centered in a side lobe may produce a stronger signal than a distant target centered in the main lobe. Moreover, at the intersection between the left-hand main lobe and a right-hand minor lobe signals of equal amplitude will appear. The array will then be pointed, not at the target, but some 25 degrees away from the target. The true lobe intersection can, however, always be determined by noting the symmetry of the signal variation as the array is moved either side of the equal-amplitude direction. The false balance is not symmetrical.

The Receiver

Two identical receivers are employed in the SCR-268, connected to the elevation and azimuth arrays. A block diagram of the receiver is

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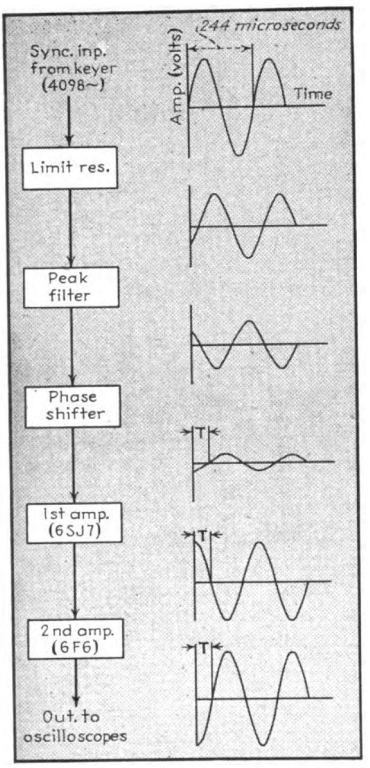

FIG. 12—Diagram showing how the SCR-268 radar range unit functions

shown in Fig. 11. Two antenna inputs are provided, for each of the two terminations of the array. These are connected to separate r-f amplifiers (type 954 acorn pentodes) which are switched alternately on and off to provide reception alternately on the respective lobes of the array.

The switching is accomplished by applying a rectangular wave of voltage to the grids of the r-f stages, the wave being obtained from a multivibrator (switch oscillator, 6N7 double triode) and a subsequent amplifier (6N7). The multivibrator produces a rectangular wave at a frequency of approximately 1400 cps. Approximately three pulses and echoes are passed through one r-f stage while the other is blocked. Thereafter, the first r-f amplifier is blocked and the second passes three pulses. In this manner reception is switched rapidly from one lobe to the other.

The two r-f stages are joined together at their plates. Hence at this point the successive lobe signals are interspersed in time sequence. Thereafter, the joint signal is amplified by a second r-f stage (954).

The tuned circuits associated with the r-f stages consist of a single inductance, permeability tuned and loaded with resistance to present a bandwidth of about one megacycle. This bandwidth is somewhat greater than the spectrum occupied by the incoming pulses, the extra space being provided to cover possible shifts in transmitter frequency.

At the output of the second r-f stage, the signal is mixed with a local oscillator signal. This signal is derived from a type-955 acorn triode oscillator in a Hartley circuit, followed by a 954 buffer stage. The mixer tube is a 954, with the pulse signal and local oscillator output applied jointly to its control grid. At the output of the mixer the difference frequency of 19.5 Mc appears.

The 19.5 Mc intermediate frequency is amplified in four i-f stages (6SK7), coupled with single tuned circuits which are permeability tuned and loaded to achieve 1-Mc bandwidth. The voltage gain of each stage is about 12, or 12^4 = 21,000 overall for the four stages.

The second detector is a triode (6SJ7) operated at cut-off bias. The detector feeds a video amplifier (6SJ7) having a gain of about 2.5. The output (taken from the plate of the video amplifier) is about 10 volts peak-to-peak maximum into a 500-ohm output circuit. Any signal higher than this saturates the video amplifier.

The sensitivity of the receiver is such that, at maximum gain, the noise developed at the receiver input will saturate the video amplifier. Sensitivity is controlled remotely, from a control associated with the cathode-ray indicator. The sensitivity control voltage is applied to the cathode of the first i-f stage.

In addition to the video output, the receiver provides a "spread voltage" for separating the indications of the two lobes on the cathode-ray indicator screen. The spread voltage is derived from the output of the switching amplifier. To assure that the gain in the two lobe channels is equal, a balance control is provided in one of the first r-f stages. This balance control is set during the calibration procedure, using a standard signal generator.

The Range Unit

The range unit is a device which controls the timing of the indicator traces relative to the production of the transmitted pulses. The range unit shown in the block diagram of Fig. 12 is essentially a phase shifter, capable of shifting the phase of the 4098-cps sine wave by any amount, continuously and smoothly.

The input 4098-cps wave is derived from the keyer (shown in Fig. 4). After passage through a limiting resistor, and through a filter to remove harmonics, the sine-wave is passed through a Helmholtz coil. This device consists of two sets of stator coils, arranged at right angles. The current fed one set of coils is advanced 90 electrical degrees by passage through a capacitor-resistor network. The result is a rotating magnetic field at the center of the coil system. This field induces a sine-wave voltage in a small pickup coil at the center of the system. The phase of the induced voltage is fixed so long as the pick-up coil is stationary. When the coil is rotated, the phase shifts in direct proportion to the angular motion of the coil. The induced voltage is amplified in two stages and the output is fed to the indicators as subsequently described.

The Indicator Units

Three identical units are used as indicators by the range, elevation and azimuth receiving antenna array operators. These indicators are very similar in appearance and function to a conventional cathode-ray oscilloscope. Besides the basic power supply, the indicator units derive three voltages from the other units of the radar: (1) the pulse signal from the video amplifier of the associated receiver, (2) the spread voltage from the switch amplifier of the receiver, and (3) the phase-shifted 4098-cps sinewave from the range unit.

A block diagram of one indicator, showing its waveforms, is given in Fig. 13. The basic synchronizing input comes from the range unit. This sinewave voltage is first amplified in an over-driven sync ampli-

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er (6AC7). The negative grid voltage cutoff and positive grid current saturation convert the sinewave input into a more nearly rectangular wave which is fed to a pulse generator (6L6), also overdriven. In the plate of this high-current tube is an inductance. The sudden current changes at the sides of the rectangular wave, passing through this inductance, induce high peaks of voltage which are used to control the following sweep-voltage generator after passing through a peak filter.

The sweep generator consists of a capacitor, charged through the 6L6 sweep generator tube. The approximately constant current characteristic of the 6L6 results in a closely linear increase in voltage across the sweep capacitor until the sudden positive peak arrives from the preceding peak filter. Then the capacitor is suddenly discharged by the heavy reverse current passed by the sweep generator tube. The result is that the voltage across the sweep capacitor has the saw-tooth form required for deflecting the electrostatic cathode-ray tube.

Before application to the c-r tube, the sweep voltage is amplified (6SJ7) and mixed with the spread voltage. The spread voltage, which we recall is synchronous with the lobe-switching, is amplified (6SJ7) and causes the saw-tooth sweep wave to be displaced bodily upward and downward, as shown in the figure. Thus the sweep associated with the one lobe-channel is displaced horizontally on the c-r tube with respect to the sweep associated with the other lobe-channel. This causes the image to appear "split" as shown at the bottom right in the diagram.

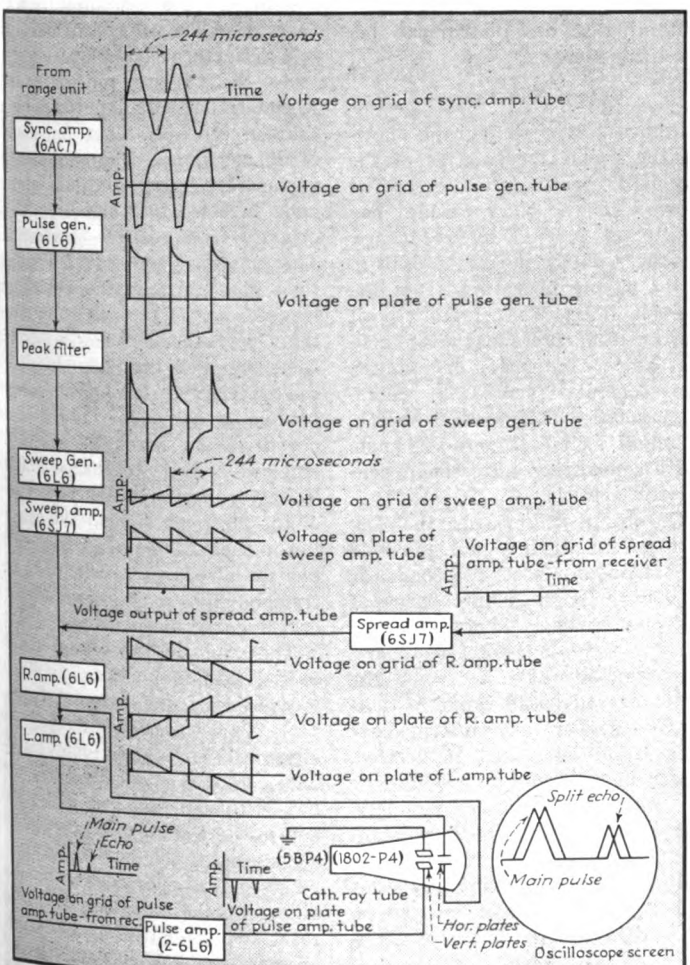

FIG. 13—Functional block diagram of one of the three oscilloscope indicating units

The displaced sawtooth wave is applied to two amplifiers (6L6's) which produce symmetrical waves of opposite polarity for application to the horizontal deflection plates of the c-r tube. The symmetry is essential to produce a linear sweep.

The receiver output is amplified in a pulse amplifier (2-6L6's) and then applied to the vertical deflection plates. The resulting screen pattern is a series of pulses in pairs. The first pair is a split image of the transmitted pulse, which is transmitted directly from the transmitting array to the receiving array. The receiver is considerably overloaded at this instant, and the pulse saturates the amplifiers and hence is flattened at the top. No special device is provided to protect the receiver during the transmitted pulse. The next pair of pulses to the right is a split image of the pulse echo from a target.

In operation, the azimuth and elevation operators adjust the spread voltage and the amplitude of the pulses until the split image is displayed conveniently for comparison of the amplitudes of the two components of the split image. Thereupon the angular orientation of the corresponding array is adjusted until both components are of equal height. The array is then pointed directly at the target.

Range Indicator

The range indicator does not make use of the spread voltage so only a single image appears for each echo. The range operator adjusts the phase shift of the range unit until the target echo appears under a cross-hair on the associated scope screen. The range to the target is then read off the phase-shift dial, which is calibrated in thousands of yards.

The SCR-268 employs 110 vacuum tubes, which are divided among the several units as follows: high voltage rectifier 4, keyer 11, range unit 3, modulator 10, transmitter 16, two receivers 15 each, three indicators 12 each. Despite this fact, and the evident complexity of the circuits, the 268 has proved to have outstanding serviceability in the field. —D.G.F.

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(1) Fink, D. G., The Radar Equation, *Electronics*, p. 92, April 1945.

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TRANSIENT PEAK

By C. RYERSON and M. ARONSON

Naval Ordnance Laboratory
Washington, D. C.

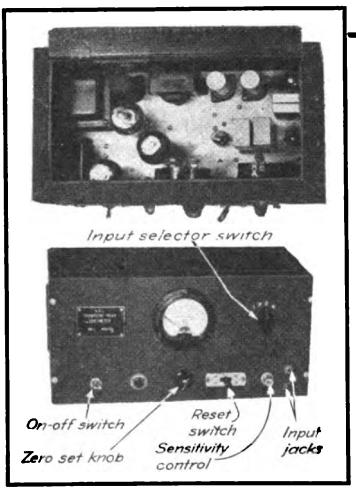

FIG. 1—Top and panel views of the transient peak voltmeter

THE INCREASED USE of single transient voltage pulses in special electronic applications has created the need for a device which can measure such pulses quickly and accurately.

Since neither d-c nor continuous-wave a-c voltmeters respond fast enough to short-period voltage changes, attempts have been made to perform this function by employing oscillographic apparatus or special observational techniques. Although adequate in some cases, such methods are at best time-consuming and involve the use of specialized equipment which is hard to obtain. Moreover, experience indicates that to employ these methods properly requires considerable practice and that the operating techniques are essentially difficult to teach the average technical worker.

The authors of this paper have designed a compact transient peak voltmeter which will measure fast voltage surges as easily as a standard voltmeter measures voltage of longer duration. It contains standard electronic components and an easily read panel-type meter. No particular operational technique is required.

The transient peak voltmeter to be described uses the fast transient signal of the circuit under test to charge a low-leakage capacitor through a diode in the voltmeter circuit. The high inverse impedance of this diode allows the capacitor to remain charged for a considerably longer period than that of the signal. By making the capacitor's discharge time sufficiently long, the initial charge can be measured by means of a high input impedance balanced bridge containing a d-c instrument between the arms.

General Description

Figure 1 is a photograph showing the simple construction of the transient peak voltmeter. The housing is a black-crackle box measuring 7 by 7 by 14 inches. Power is obtained from a built-in power supply operating from the 115-volt line. The entire circuit uses but four tubes and a 0-to-200-microampere indicating instrument. The controls include a range-adjustment switch, a reset switch, an on-off switch, a zero-set knob, and a screwdriver-adjustment sensitivity control.

The circuit will measure the peak value of the input signal and hold the reading for several seconds, or until reset by the manipulation of the reset switch. There are four input voltage ranges of 1, 5, 10, and 50 volts full scale, to cover the most generally used range of voltages. Higher or intermediate ranges can be added if desired. Lower ranges could be provided by the addition of suitable amplifiers. The input circuit has a constant input impedance of 20 megohms and contains a blocking capacitor which prevents direct current in the measured circuit from affecting a measurement.

The frequency response characteristics of such a voltmeter can best be considered as the response to single transients with various times to the peak. Assuming the pulses to be the equivalent of one-half cycle of sine wave, the response is flat within 2 db from five milliseconds to one-half second and time to the peak.

Circuit Theory

Figure 2 is a block diagram illustrating the essential circuit functions. The voltage divider (A) is a resistance network which provides the various voltage ranges to match the signal input and maintains a constant input impedance of 20 megohms. The amplifier-inverter (B) provides a gain of ten and inverts the signal voltage polarity from positive to negative. The amplified and inverted signal then goes through the impedance transformer (C) which is no more than a cathode follower circuit used to match the plate circuit of the amplifier to the low-impedance hold-on circuit (D). The hold-on circuit is an arrangement which employs a diode to charge a low-leakage capacitor to the peak value of the incoming signal. The charging impedance of this circuit is low but the discharge resistance is extremely high, in the order of several hundred megohms.

The value of the voltage which is fed into the hold-on circuit is measured by the balanced bridge (E). This voltmeter circuit is designed to have high input resistance, so that the signal will not be dissipated by the measuring device. At the conclusion of a measurement the hold-on circuit is reset and made ready for a new signal by the manipulation of the reset switch (F). This action discharges the hold-on capacitor.

Figure 3 shows a simplified version of the circuit schematic

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VOLTMETER

The amplitude of a single short pulse is determined by amplifying the transient voltage, then charging a capacitor through a hold-on circuit which permits the charge to be maintained long enough for measurement by means of a balanced-bridge d-c voltmeter equipped with a 0 to 200-microampere indicating instrument

in which the blocks of Fig. 2 have been replaced by appropriate circuit components, the order remaining the same. The functions which have just been outlined can better be understood by a comparison of these two figures.

A few additional features will be noted in Fig. 3 and 4. The potentiometer control R_1 adjusts the sensitivity of the voltmeter and is used during calibration. The control R_2 is the zero-set adjustment which provides balance between the tubes of the voltmeter bridge.

The voltmeter bridge is a double cathode follower arrangement, with the input signal applied to the grid of tube VT_3, the balance potential applied to the grid of VT_4, and the indicating instrument connected between the cathodes of these two tubes.

Figure 4 is a complete schematic diagram of the transient peak voltmeter, showing all electrical details. The compensation network in the grid circuit of the cathode follower tube VT_3, consisting of resistances R_3, R_4 and C_1, improves the frequency response of the preceding amplifier tube VT_2 by increasing the input impedance of the cathode follower circuit. The bias cell in the input to VT_3 is necessary in order to cancel the diode potential which otherwise would cause a spurious zero reading. The presence of this cell requires that the reset switch be connected to discharge the capacitor without shunting the bias cell.

The voltage which is applied across the balance or zero set resistor R_2 is in practice obtained from a small C-battery. This arrangement is more stable than the method shown in Fig. 3 except when a B-supply which is regulated against output voltage fluctuations is used.

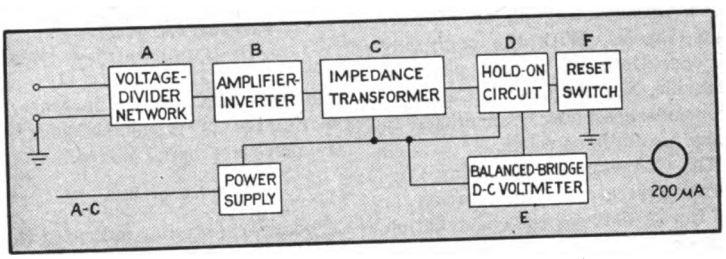

FIG. 2—Block diagram showing essential circuit functions

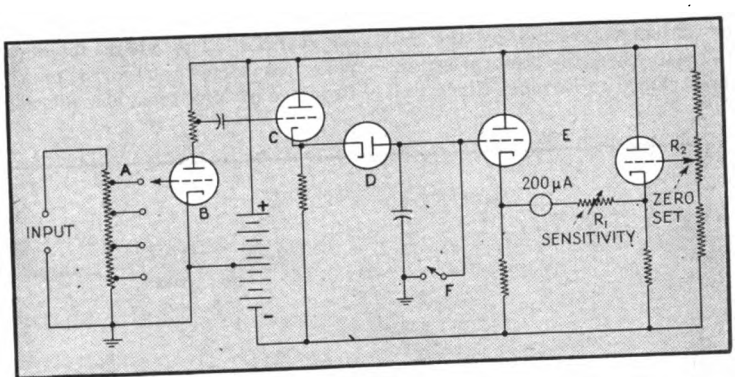

FIG. 3—Simplified circuit diagram. Identifying letters correspond to those in Fig. 2

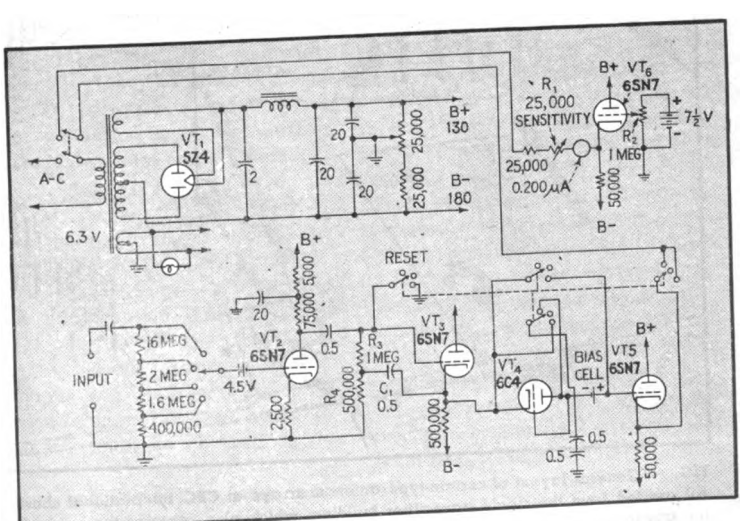

FIG. 4—Complete transient peak voltmeter circuit

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Canada's INTERNATIONAL

By H. M. SMITH
Maritimes Regional Engineer
Canadian Broadcasting Corp.
Sackville, New Brunswick

CANADA has now joined those nations which have undertaken broadcasting on an international basis. With the beginning of operations of a new plant at Sackville, New Brunswick, Canadian programs are being transmitted to many parts of the world.

The Canadian Broadcasting Corporation received authorization in the fall of 1942 for the construction and operation of a major short-wave plant. The building was completed, two 50-kw transmitters and speech input equipment installed, and antennas erected by the fall of 1944, when the first programs were beamed to Europe. Since that time there has been an increase in the number of transmissions, and still more are being added.

Choice of Site

Theoretical studies indicated that the plant would have to be located in the eastern part of Canada if minimum trouble from the earth's magnetic field distribution were to be realized. The north magnetic pole lies somewhat north of the Province of Manitoba, considerably south of the geographic pole. This results in a region of relatively high flux density, usually known as the disturbed zone, extending radially from the magnetic pole for several hundred miles. Both theory and experience indicated the wisdom of locating outside of this zone.

Previous experimental investigations of transatlantic reception had been carried out by the Engineering Division of the CBC. BBC programs on various frequencies were recorded simultaneously at Ottawa and at a location south of Halifax on the Atlantic coast. Simultaneous records of field intensity were also made at these points. An im-

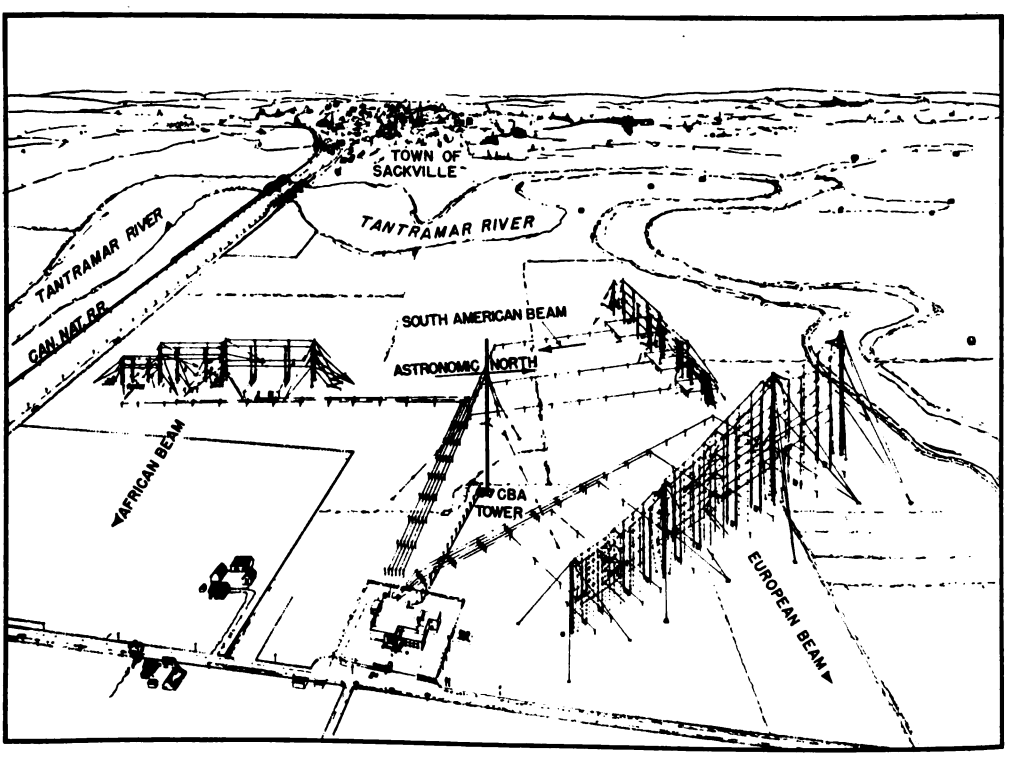

FIG. 1—General layout of curtain-type antenna arrays at CBC international short-wave plant at Sackville, New Brunswick. All are fed from the single transmitter building, which also contains the original 50-kw broadcast-band transmitter feeding the guyed vertical radiator of station CBA. All three beams can be reversed, as well as electronically slewed a few degrees off their normal paths. The European beam system has much higher gain than the others

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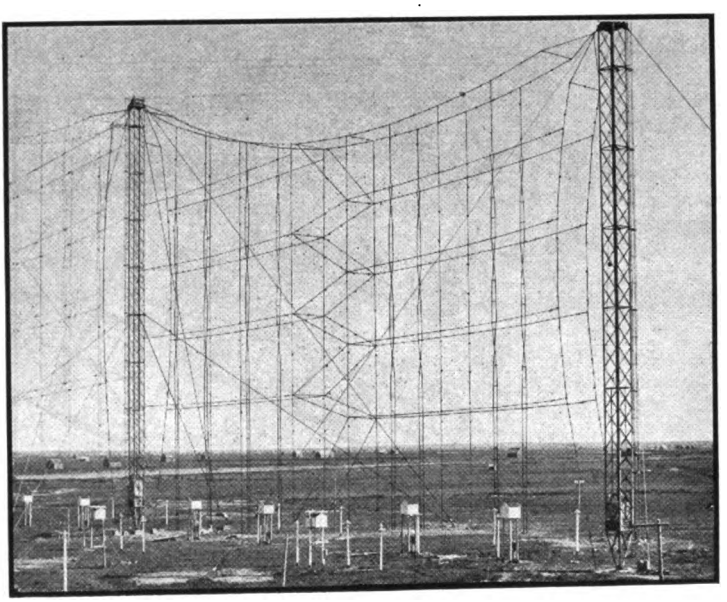
SHORT-WAVE PLANT

Description of facilities newly installed at Sackville, New Brunswick, for operation in the 6, 9, 11, 15 and 17-mc bands. High-gain curtain-type antenna arrays are beamed in three directions, with slewing systems for covering areas wider than the usual beam width

provement of several db in signal strength was obtained, and the amount and nature of fading was very strongly in favor of the eastern location. While other factors entered into the selection of the site this work could not be ignored.

The CBC had previously located one of its 50-kw broadcast stations, CBA, at Sackville, New Brunswick, a town near the border of Nova Scotia and approximately 90 airline miles northwest of Halifax. In this part of New Brunswick there are extensive marsh areas—large bodies of land reclaimed for agriculture from the tidal waters of the Bay of Fundy by dyking. This low-lying, rich soil is continually moist, an asset for ground systems. The town is well served by transportation, both rail and highway. Further advantages included existing staff and program line facilities. The decision was therefore taken to locate at Sackville, and previous property holdings were increased to approximately 200 acres of land.



Details of typical curtain-type arrays. The 17-mc array is to the right of the zig-zag suspension cables, and the 15-mc array is to the left. The tiny houses near the ground contain switching relays

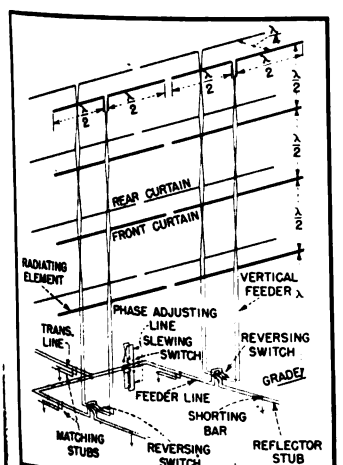


FIG. 2—Curtain-type array for a single frequency, with reversing and slewing switches shown schematically

Selection of Antennas

The plans developed called for transmission to Europe, Australia, New Zealand, South Africa and South and Central America. On laying out the beams for these areas, it became apparent that if provisions for beam reversal were included, the major land areas of the earth could be covered fairly well.

Three antenna systems were provided, being designated as European, South American and Australian. As the names imply, they were laid out for beam width and direction to these areas. Upon reversal, these antennas provided coverage to Central America and New Zealand, Eastern Asia, and South Africa, respectively. Each antenna system consists of several directional arrays for operation in the 6, 9, 11, 15 and 17-megacycle bands. Present plans call for the addition of 21-megacycle antennas in the future. The general layout of the antenna systems is shown in Fig. 1.

Considerations of site, results desired and economics led to the decision to use curtain-type antennas, rather than the simpler rhombic type having somewhat lower efficiency. It was felt, and experience

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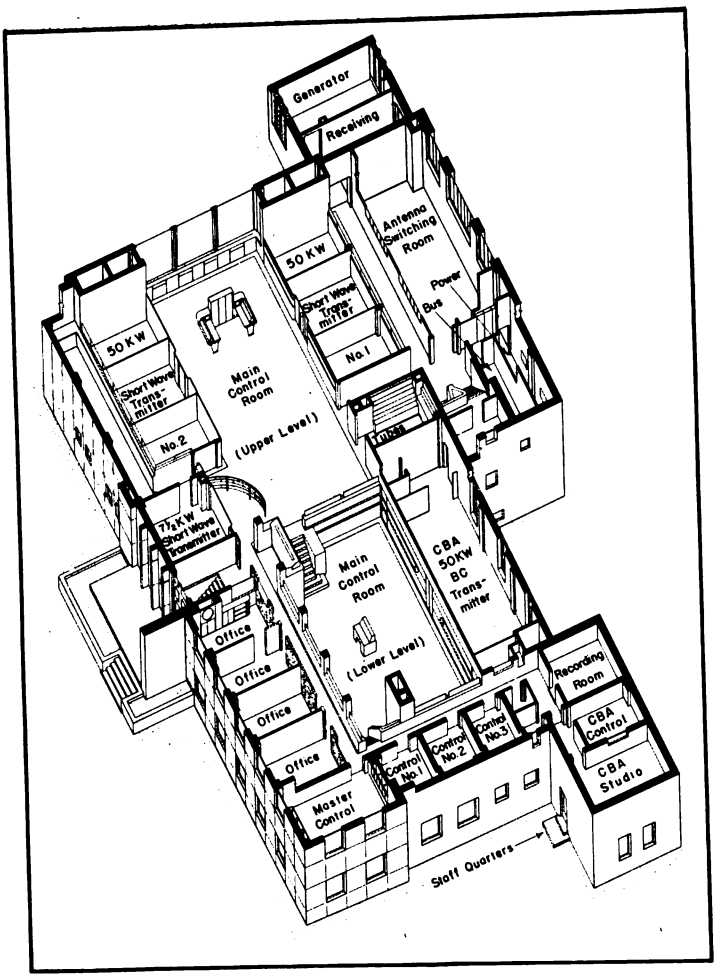

FIG. 3—Isometric view of main floor of CBC short-wave building at Sackville

confirmed, that the lower vertical angle of radiation realizable with the curtain type would materially improve reception.

Special considerations, mainly associated with the war, made it desirable to increase the field intensity directed toward Europe, and the European antenna system was therefore designed for somewhat higher gain than the others.

The antenna systems, particularly the European, are rather unique in design, and have substantial gain. Each antenna of the European system consists of a driven curtain and a nondriven reflecting curtain, identical in form and located behind the driven elements as in Fig. 2. Each curtain except the 6-mc consists of eight horizontal elements, arranged in two side-by-side vertical stacks of four; the length of each element is slightly under one wavelength. All elements of the driven curtain are driven in the same phase at their centers by vertical transmission lines. The lines from the two side-by-side stacks come together a short distance above the ground level and tie onto the main feeder line from the station. Remotely controlled reversing switches are located at the base of each of the vertical lines and are so arranged that they can connect driving power to either the front or back curtain, simultaneously connecting a stub to the undriven curtain. These switches are energized from an antenna switching panel, located in the transmitter building.

Another remotely controlled switch is located in the feeder to one of the vertical stacks of each antenna. This is arranged to feed in any one of three ways at the discretion of the controlling operator. Normally the feeder provides a circuit directly through the switch; the feed is then symmetrical with that to the other stack. In the second position the switch introduces a predetermined amount of additional feeder, thus inserting a phase delay in its stack in comparison with its companion stack. This serves to swing or slew the beam a few degrees from its normal path and provide better signal strength in desired areas which are not covered fully with the beam in its normal position. Similarly, with the switch in its third position, a phase advance is introduced in one stack, slewing the beam in the opposite direction. This arrangement provides a degree of flexibility which is useful in covering areas wider than the usual beam width.

The European system has five antennas. The 17 and 15-mc antennas are slung on messenger cables between the first two towers, the 11 and 9-mc units are between the next two, and the 6-mc unit uses the last two towers. These antennas give measured gains of slightly over 20 db. The 6-mc antenna is generally similar to those of higher frequency except that it has 6 driven elements instead of 8 and a similar arrangement in the reflecting curtain. Measurements made in England confirm the performance, in field intensity received and a reduction in fading in comparison with other antennas.

Building Design

Early in the planning the decision had to be made whether or not to house the short-wave facilities in a building separate from the CBA broadcast plant or combine them. While the latter course was much more difficult, entailing the removal of large sections of the existing building while keeping the broadcast plant in operation, the resulting overall economies and flexibility in operations led to its adoption. The old building was largely torn down above ground; temporary housing was erected over the equipment in service, and a new and larger structure built.

Fig. 3 shows the general lay-

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out of the main floor. The transmitter room is 120 feet long. It houses the two short-wave transmitters, with the CBA broadcast transmitter in a well a half story below the main floor. Heavy plate glass parapets surround the broadcast transmitter well. The walls above the transmitters and the full ceiling area of the main transmitter room are acoustically treated for high absorption.

The north section of the building houses a broadcast and two short-wave program control booths, an emergency studio, recording room and master control, all acoustically treated. This section is shielded by two concentric copper screens built into the walls and carried through the double doors leading to each of these rooms. Along the front of the building are located offices for the staff.

At the rear of the building are tube storage rooms, power distribution facilities, power metering panel, antenna switching room and stand-by generator room. A ramp at the rear of the building leads to an interior freight entrance. The basement contains additional office space, emergency staff quarters, shop, shielded laboratory. transmitter cooling and air conditioning equipment, furnace and fuel storage, together with various store-rooms for spare equipment and supplies.

The staff quarters provide a modern kitchen, dining room, lounge, showers, and three bedrooms each containing two built-in single beds. Rather severe winter storms have made it necessary to provide facilities of this type, for it is not unusual for the staff to find itself snowed in for a day or two. These quarters also have decided virtues after late engineering sessions on the equipment.

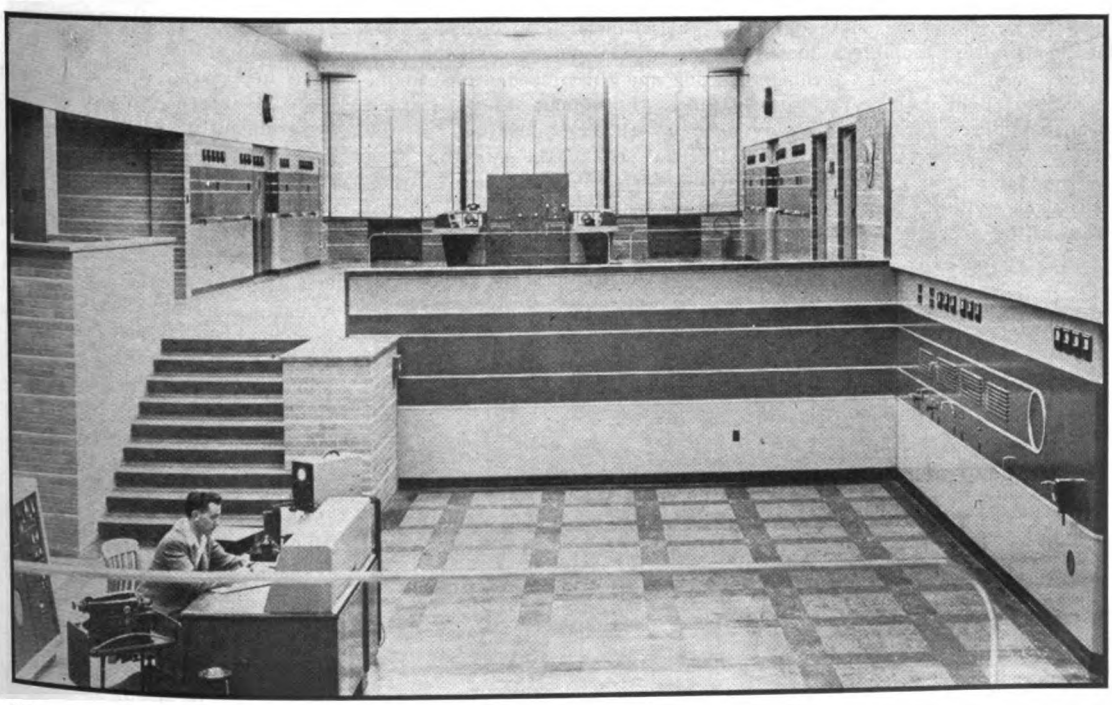
In winter some of the heat carried by the transmitter cooling equipment is injected into the air conditioning system. Two large electric stills are housed under the roof space. These discharge into a large distilled water storage tank in the basement. The water may be piped to any of the working tanks associated with the cooling systems of any of the transmitters.

Power Distribution

Three-phase 60-cycle power is obtained from a commercial steam plant about 15 miles distant from the station. It is delivered at 23 kv and brought down to 2300 volts at a substation on the property. The total load of the station is about 750 kva.

The incoming power feeds a 2300-volt bus through an oil circuit breaker. From this bus individual branch feeders lead to each of the three transmitters, the three-phase 220-volt domestic service bank, the single-phase domestic bank, and the antenna lights. A metering panel contains watthour meters for total station load, total transmitter load, short-wave transmitter No. 1, short-wave transmitter No. 2, broadcast transmitter, three-phase domestic load, single-phase domestic load, and antenna lighting load.

Three line voltmeters are permanently connected across the main 2300-volt bus and a recording voltmeter can be switched to any phase. Three ammeters, a graphic wattmeter and a recording wattmeter can be switched into any of the major loads listed previously. These facilities are not common in such service but are decidedly useful in providing information on plant operations and breaking down



Main transmitter room at Sackville, with portion of CBA broadcast transmitter at the right foreground (on lower level) and the two 50-kw short-wave transmitters at the left and right of the control consoles in the background

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operating charges. An engine-driven generator has been provided for emergency use in the event of power failure.

Equipment

Two 50-kw RCA type 7330-A transmitters are located in the building. They utilize high-level modulation and may be operated at any frequency between 6 and 21 mc, at rated output. Their auxiliary equipment, consisting of distribution, plate and modulation transformers, modulation reactor and induction regulators, are located in a large vault in the basement. The installation is generally of standard type. The inter-unit wiring of the transmitters, mainly control, is by metal troughs in the floor slab. All power circuits run in separate conduits and potheads are used on all circuits carrying 2300 volts or more. The circuits carrying high-level audio from the modulation transformer in the basement vault are run in fiber conduit hung on special insulation to reduce capacitance which might affect the feedback loops.

The two operating consoles for the short-wave transmitters have been grouped together between the transmitter fronts. Associated with them are three cabinet-type relay racks containing such equipment as limiting amplifiers, modulation monitors, and feedback amplifiers. Behind these racks are two more racks housing master oscillators of high stability. These provide r-f output at any desired frequency within the range of transmitter operation, and one is connected to each transmitter. The transmitters may be controlled by any one of four self-contained crystals or the master oscillator by operating a selector switch. A secondary frequency standard is provided for use with the master oscillators and to check the crystal frequencies.

The transmitters feed into the antenna switching room. This contains a bank of radio-frequency switches of special design permitting any transmitter to be connected to any antenna (or more properly, transmission line), or to either of two water-cooled dummy loads used for transmitter tests.

The antenna switches are mounted on dead front panels, generally similar to standard switchgear in appearance, and are handwheel operated. The switches are interlocked so that one transmitter can feed only one antenna at a time. Associated with each antenna switch are the controls for the remote reversing and slewing switches for that antenna. Status lights show the operating conditions of each transmitter, whether the particular antenna is operating direct or reversed and also the direction of slew or otherwise. These status lights are multiplied to a panel at the operating console.

The transmitters operate into loads of 415 ohms in this installation and this impedance is maintained throughout the switching and to the r-f bushings in the interior wall of the building. The characteristic impedance is then raised to 552 ohms by a tapered section of line and continues to the antennas in this latter value. Considerable refinement in design was necessary to maintain a constant value of impedance throughout the switching system, for all conditions of switching. This was accomplished, however, and the standing wave ratio is affected to a negligible degree.

A standing wave ratio indicator is mounted in the antenna switching room. It is so arranged that a meter gives a direct scale reading of the standing wave ratio and may be switched into any feed. The transmission lines are generally conventional and of balanced two-wire type. They are constructed of 1/0 stranded copper and carried on suspension-type insulators.

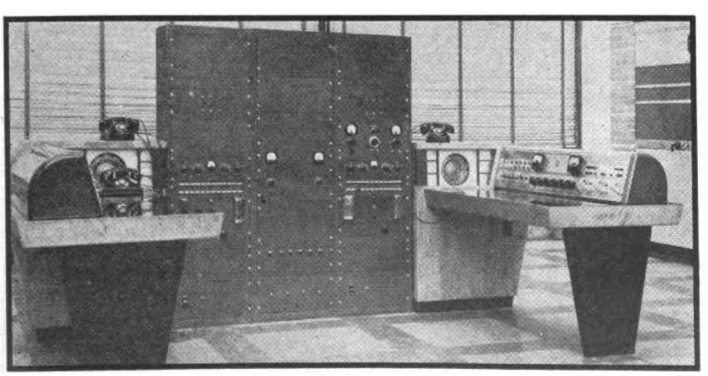
Audio and Program Facilities

A complete unit of the CBC, including program, technical, traffic and administrative staff, was set up in Montreal for international broadcasting. Studios, recording rooms and master control were provided to feed the Sackville plant directly over program lines some hundreds of miles long, provided by Canadian National Telegraphs and Canadian Pacific Telegraphs.

To protect against occasional line difficulties, recording facilities have been provided at Sackville so that programs may be pre-recorded there and stored for a few hours or as necessary. Announce booths have also been provided so that the transmitting plant can operate, for a reasonable emergency period, independently of the Montreal studios.

These requirements, in addition to the normal broadcast and control circuits, led to the provision of a master control at Sackville. This is of the preset type and can handle up to six simultaneous programs. Monitor circuits provide for selection of any incoming or outgoing program as well as the rectified r-f output of any transmitter. Each monitor position can select any of these feeds by a dial selector unit. Monitor positions are located at all transmitter control positions, master control and offices.

The whole plant was planned and designed by members of the engineering division of the CBC, under the direction of the chief engineer, G. W. Olive.



Control consoles for the two short-wave transmitters, with auxiliary equipment in relay racks in background

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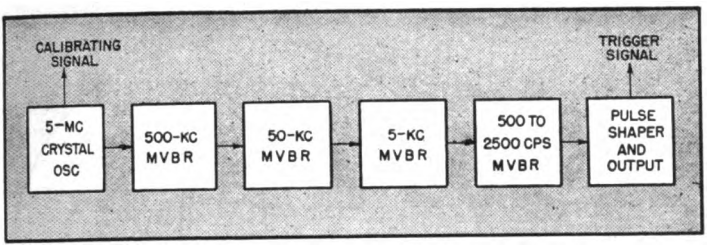

Time-base calibration requires a constant-frequency calibrating signal and a synchronized pulse to trigger the sweep. A crystal-controlled oscillator provides the calibrating signal; multivibrator frequency-dividers provide the relatively long-period, short-duration synchronized triggering pulses

TIME-BASE CALIBRATION

Time-displacement linearity of oscilloscope sweeps can be measured at tenth-microsecond intervals by using a crystal-controlled, driven multivibrator chain. Circuit provides sweep-triggering pulse and constant-amplitude, continuous calibrating signal

By WALTER W. LUDMAN
Philadelphia, Pa.

TESTING of certain electronic equipment requires the measurement of the width or duration of extremely narrow, rectangular, recurrent pulses. Some of these pulses may have durations as short as one-half microsecond. It may be necessary to measure the duration of such pulses to an accuracy of 2 per cent.

Synchroscope

Measurement of such short-duration pulses is usually accomplished with the aid of a device generally known as a synchroscope. This is primarily an oscilloscope with a triggered sweep circuit supplying, for the horizontal deflecting plates of a c-r tube, a deflection voltage which varies at an unusually high speed and has a very linear rate of change. Provision is made for applying the pulse to be measured directly to the vertical deflecting plates of the c-r tube.

The horizontal sweep voltage or time base varies at a rate such that its total voltage swing may occur in a time interval of only 3 or 4 microseconds; the time between successive sweeps may however be very long in comparison, 1000 microseconds in the example shown in Fig. 1.

The time interval between successive sweeps is controlled by the recurrence rate of the trigger signal which starts the sweep circuit functioning. This trigger signal can be supplied by circuits within the synchroscope or from some external source, but it must be in synchronism with the recurrence rate of the signal to be viewed.

When a pulse having a duration of only one microsecond is viewed on an oscilloscope provided with a sweep having a duration of 3 microseconds, a pattern is obtained as shown in Fig. 2. Very accurate measurements of the actual duration of the pulse at any amplitude can be made if the exact time rate of change per unit of deflection of the horizontal sweep is known. Various methods can be used for calibrating such a time base in terms of microseconds per inch of deflection.

Calibration Techniques

Most calibrating schemes are based on the application of a sine-wave signal of known frequency to the vertical channel of the oscilloscope. If the frequency is known, the time interval between successive cycles of the sine wave is simply $T = 1/F$ seconds or $10^6/F$ microseconds. Thus a frequency of one megacycle would have a time interval of one microsecond between successive cycles.

In order to make use of such a sine-wave calibrating signal it is necessary that the signal be synchronized with the trigger signal which starts the time base. This requirement has led to the general adoption of various forms of shock-excited oscillators. Circuits of this type are arranged to deliver a damped wave train of oscillations when excited by the same trigger voltage which initiates the sweep oscillator. The time interval between successive cycles of the damped wave is governed by a tuned circuit which is resonant at the desired frequency.

The disadvantages of this method are: (1) Since the frequency is determined by a simple tuned circuit, its alignment must be checked frequently. (2) The frequency of the tuned circuit can only be checked while it is operated in a continuous-wave oscillator circuit. Whether the resonant frequency remains the same under conditions of shock ex-

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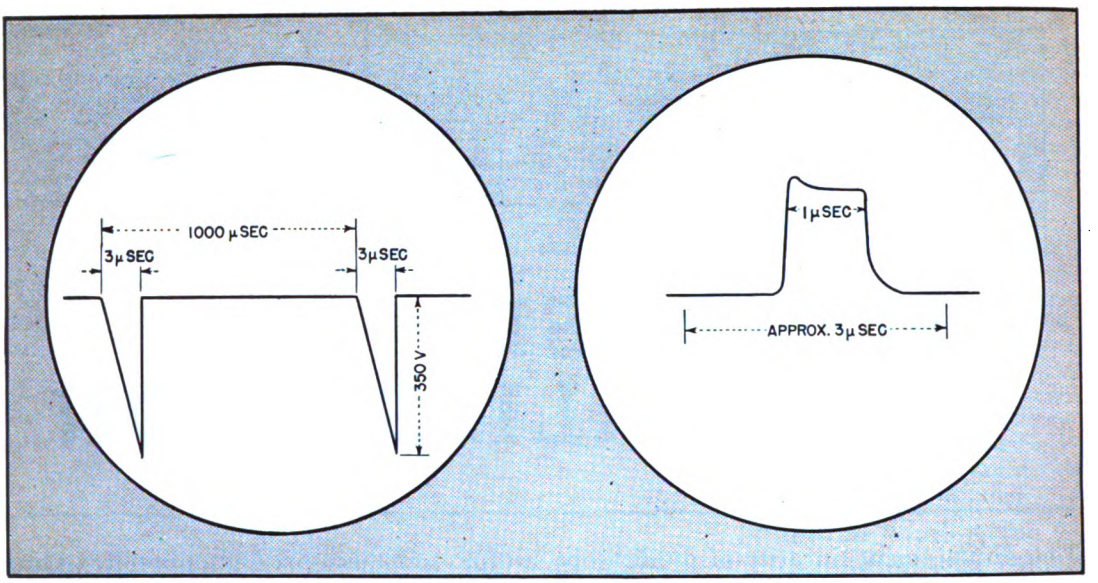

FIG. 1—Typical pulse sequence, showing the long and short periods that must be accommodated by a time-base calibrator

FIG. 2—One-microsecond pulse can appear distorted when viewed on a high-speed time base if the sweep is non-linear

citation is questionable. (3) A damped wave train may introduce errors because the time interval of each cycle is not the same.

To overcome these drawbacks the system shown in the block diagram is used. The unit contains a 5-mc crystal-controlled oscillator which supplies the calibrating signal. Because the time interval between cycles is 0.2 microsecond, calibrating intervals of 0.1 microsecond are readily available.

Following the crystal oscillator is a series of multivibrators used as frequency dividers. The first, operating at 500 kc, is synchronized directly from the crystal oscillator. It, in turn, synchronizes a 50-kc stage which in turn locks in a 5-kc multivibrator. The output of this multivibrator synchronizes a fourth, whose frequency is variable in synchronized steps from 500 to 2500 cps.

The output of the last multivibrator is fed through a pulse-shaping amplifier, a variable delay network and finally a cathode-loaded output stage. The function of the frequency dividers and pulse-shaping stage is to produce a pulse which is synchronized with the calibration signal and suitable for use as a trigger pulse to trigger the sweep circuit in the oscilloscope.

When the oscilloscope sweep is

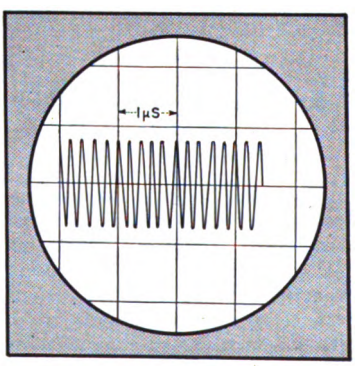

FIG. 3—Constant-amplitude, fixed-frequency sine wave serves to mark microsecond intervals on sweep for linearity calibration

triggered by this pulse and the calibrating signal from the crystal oscillator applied to the vertical plates of the c-r tube, the stationary sine wave pattern of Fig. 3 is obtained. The variable delay control in the input to the cathode-loaded output stage permits positioning the calibration signal anywhere along the time base.

As previously pointed out, the time interval between successive peaks of the same polarity is 0.2 microsecond. If the sweep speed is adjusted until exactly five peaks coincide with one inch of deflection, the time base can be considered to have an accurate calibration of one microsecond per inch of deflection. If the sweep speed is adjusted for 10 peaks per inch, the calibration is equivalent to 2 microseconds per inch.

Calibrator Circuit

The circuit shown in Fig. 4 is, with few exceptions, straightforward and requires little explanation. The final multivibrator is made variable in frequency so that the oscilloscope sweep circuit can be triggered at the same repetition rate while being calibrated as when being used for measurements. This multivibrator is also of the unbalanced variety, i.e., the circuit constants of the two sections of the dual tube comprising the multivibrator are considerably different. As a result, one half-cycle of the signal is much shorter in duration than the other half. This permits obtaining a pulse of comparatively short duration. Because the shorter part of the cycle appears as a negative pulse on the plate of the left-hand triode, the output of this section is applied to a zero-bias amplifier which permits the negative half-cycle to be amplified while tending to clip the positive half-cycle. The amplitude of the negative peak is sufficient to drive the amplifier grid to cutoff thus squaring the peak.

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The combination of the 25,000-ohm rheostat and 15-$\mu\mu$f capacitor produces a phase shift which is capable of making the signal applied to the grid of the cathode-loaded stage lag the signal at the plate of the preceding tube by almost one microsecond.

The output signal is a positive pulse having an amplitude of approximately 20 volts peak and a duration at 80 percent of peak of about 12 microseconds. The output of the crystal oscillator is approximately 70 volts peak to peak.

Use of Calibrator

To insure utmost accuracy of calibration and measurement certain precautions have to be observed. First, before the time base is calibrated, the sweep should be positioned by means of the position control so that the start of the sweep is at some definite reference point. Once this adjustment is made and the calibration performed for this setting, all measurements should be made with the sweep starting at the same reference point.

Second, when calibrating the time base, the calibration should be made for a certain definite portion of the sweep (usually the one inch nearest the center of the oscilloscope). All future measurements should then be made on the same portion of the sweep. These two precautions eliminate possible error due to non-linearity of the sweep or non-linearity of the c-r tube deflection.

Also, it is advantageous to use the peaks of the calibration signal which are nearest the vertical portion of the c-r tube face used in making measurements. Thus if negative pulses are to be measured on the scope, the negative peaks of the calibrating signal would be nearest to the portion of the tube face on which the measurement is to be made. If measurements are made at the vertical center of the screen, it may be an advantage to use the zero crossover portion of the sine wave.

Advantages of Calibrator

The equipment described has certain desirable features not found in calibrators using such methods as triggered shock-excited oscillators. First of all, because the calibration signal is crystal-controlled and operates continuously, the calibration signal covers the entire duration of the sweep and has a constant amplitude over the whole sweep.

The use of a 5-mc calibrating signal enables the calibration of the sweep to be done at points of one microsecond and one-half microsecond per inch of sweep with high accuracy. The unit can also be easily adapted to the calibration of slower speed sweeps by utilizing the output of the intermediate multivibrators for a calibrating signal. For example, the 500-kc multivibrator could be used for obtaining 2-microsecond time intervals, 20-microsecond points can be obtained from the 50-kc multivibrator and 200-microsecond intervals from the 5-kc multivibrator.

To make use of the intermediate frequencies for calibrating purposes it would be desirable to pass the output of the multivibrator through an amplifier which has a differentiating network in its grid circuit. This practice would provide sharp, spike-like pulses that would permit sharper calibration.

In setting up the unit and adjusting the multivibrators to synchronize on the proper frequencies a single or multiple loop Lissajou pattern can be produced on an oscilloscope by using the multivibrator output and a standard signal generator. The dual potentiometer in the grid circuit of the multivibrator is varied until the Lissajou pattern is synchronized; that is, appears stationary. An alternate method is to use the output of the crystal oscillator or the preceding multivibrator in place of the signal generator. The final multivibrator can best be checked for frequency range by comparing its output to an audio-frequency signal on the oscilloscope.

Units of this type have been in use by the writer for several years for calibrating oscilloscopes. The results have been consistently reliable. Few readjustments of the multivibrators have been necessary.

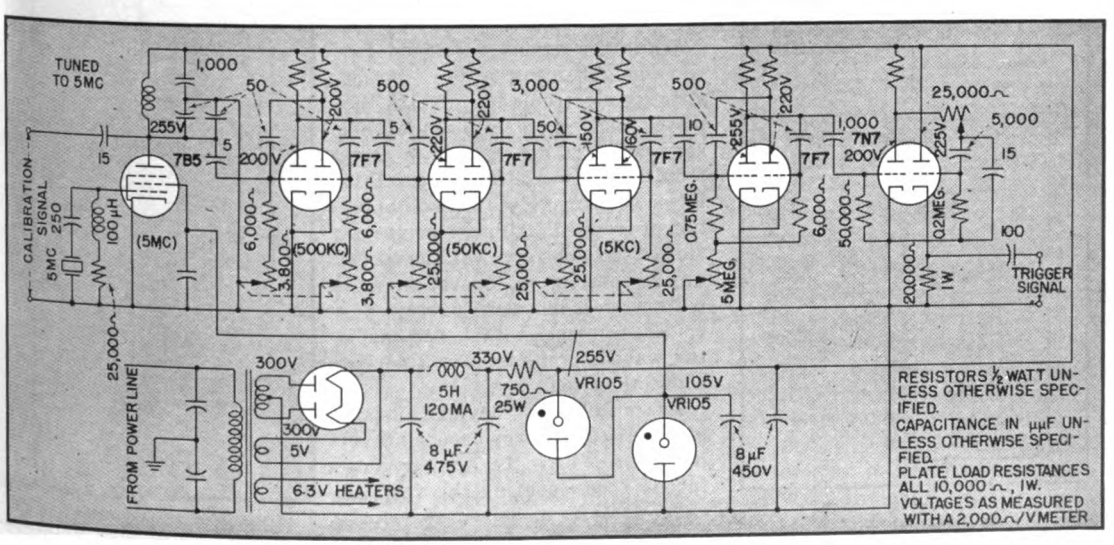

FIG. 4—Circuit of self-contained time-base calibrator which can be built for rack mounting or test-bench use

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Electronics Aids

Breakwater, levee, dam, lock and other marine experiments performed with models utilize electron tubes for the determination of wave heights and water pressures. Earth pressures are recorded in a manner which lends itself to the testing of airport runway pavements. Special relay-booster and timing circuits are also used

By EUGENE H. WOODMAN

Chief, Electrical and Mechanical Section
U. S. Waterways Experiment Station
Vicksburg, Miss.

ONE OF THE AGENCIES of the Corps of Engineers, War Department, which has consistently done its part toward victory is the U. S. Waterways Experiment Station. Established in 1929 for the primary purpose of making hydraulic model studies of the Mississippi River and other recalcitrant streams and, through an associated soil mechanics laboratory, making improvements in levee and dam design, the activities of this agency have more recently been devoted to problems of harbor protection and improvement and airport design as well as other related investigations concerned with the war effort.

One of the most important adjuncts of this investigative agency lies in the instrumentation developed for specific requirements dictated by the complex techniques employed in the solution of modern hydraulics and soil mechanics problems. It is the purpose of this paper to describe some of the electronic devices which have recently found application in the successful solution of several difficult problems. The instrumentation to be described includes wave-height measuring apparatus for breakwater and harbor studies, pressure cells designed to determine both water and earth pressures, deflection gages used in pavement studies, and timing apparatus for velocity determination by means of float measurements. Other devices in use or under development are briefly mentioned.

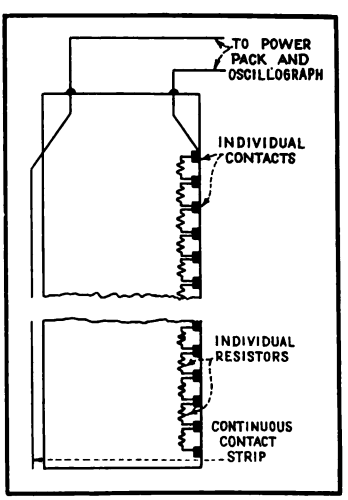

FIG. 1—Schematic of a staff which facilitates determination of wave heights. A photograph of the staff is shown in Fig. 2

Wave-Height Measurement

While the device developed for wave-height measurement is not strictly electronic in itself, the power unit supplying the necessary constant d-c voltage is electronically controlled. It is this latter refinement, with its elimination of frequent calibrations necessitated by battery voltage drop during periods of operation and battery rejuvenation during periods of idleness, that has made the wave-height measuring device a practical tool.

Essentially, this device consists of a vertical staff or case containing a series of individual contacts in one face, covering the vertical range of water movement expected, and a continuous contact on the opposite face, as illustrated in Fig. 1. Small (½-watt) resistors are interconnected between the individual contacts. These resistors are contained within the case, as shown in Fig. 2, except when limited by reduced physical dimensions of the cases used on small-scale models, where closer contact spacing and a small cross-sectional area are necessary because of diminutive characteristics of the wave patterns. In such instances, the resistors are mounted on a cross-arm located above high-water elevation and the interconnections to the individual contacts are made with small-gage wires running up through the case to the cross-arm.

The principle utilized in the wave-height measuring device involves the fact that a water path can serve to complete an electrical circuit between two points (in this

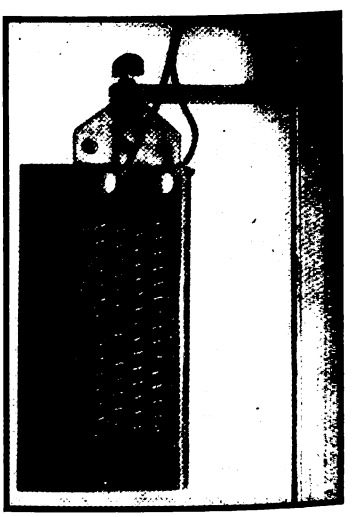

FIG. 2—Photograph of the wave-height measuring staff shown schematically in Fig. 1. Resistors are within the staff and their leads form contacts

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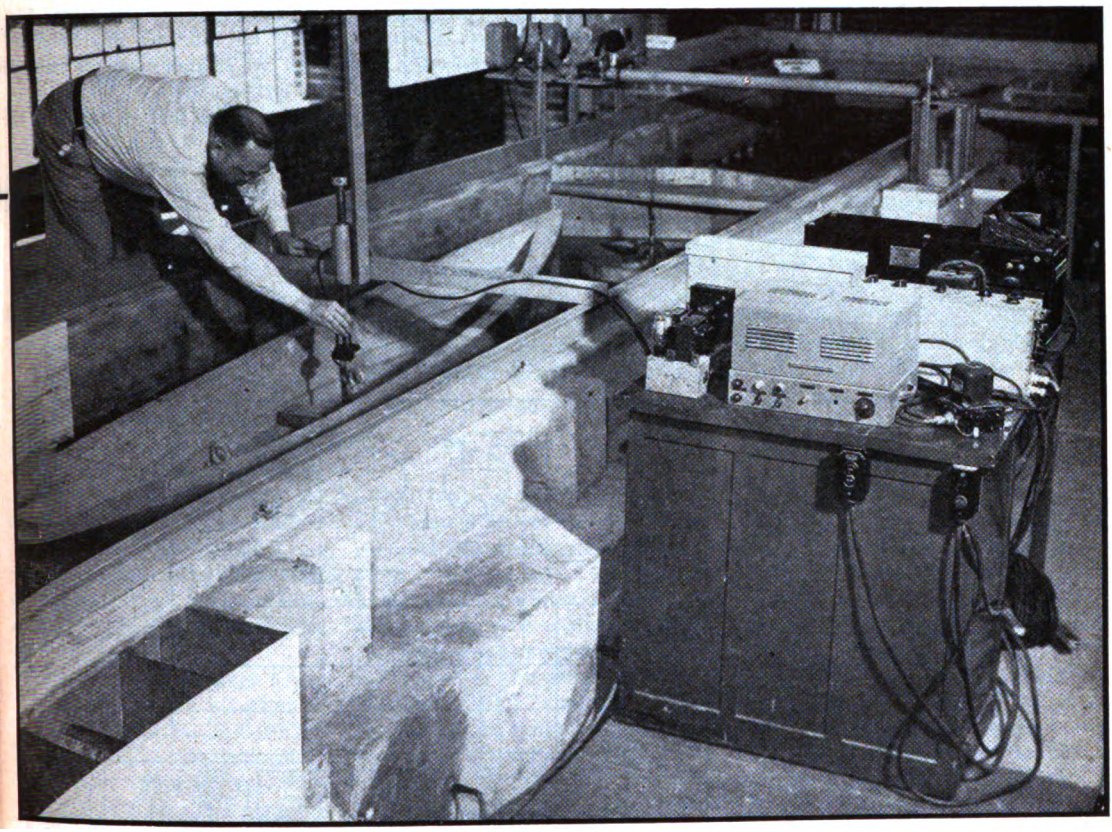
Waterway Development



Resistance-wire strain gages and associated electronic equipment measure hawser pull on a model ship entering a canal lock

instance, the continuous contact strip on one face of the case and whichever of the individual contacts on the other face is located on the water surface at that instant). The resistance of this electrical circuit can be made to vary in inverse proportion with variations in the water-surface elevation by suitable calculation of the individual resistors installed between contacts. Thus, when a constant d-c voltage is impressed across the terminals of the resistance staff, the resulting current changes in the electrical circuit will correspond directly with changes in water-surface elevation, or wave height.

The calibration curve shown in Fig. 3 represents the oscillograph deflections obtained in calibrating a wave-height measuring device with a 2½-foot range. This calibration was obtained by making incremental variations of the submergence of the resistance staff in still water and observing the corresponding deflections of the galvanometer beam. It should be noted at this point that a continuous curve is obtained on the oscillogram as the resistance staff is moved through its range in the water. Although in theory a stepped record would be obtained as determined by the spacing of the individual contacts, in actuality the variation in contact area as the staff is submerged is sufficient to result in a practically continuous curve. Resistance of the water path remains fairly constant throughout the operating range; any possible error from this variable and from changes in the conductivity of the water is eliminated by the use of a current-limiting resistor included in the calculations of individual resistor values; it has not been found necessary to add salt to the water or otherwise alter its natural conductivity.

A constant d-c voltage must be impressed on the terminals of the resistance staff. It is obvious that this device is voltage-sensitive in regard to calibration. It was found in practice that there were slight irregularities in the output of a conventional power supply operating from the a-c lines, even when voltage regulator tubes were used. Futhermore, the output of such a device contained traces of 60 and 120-cycle voltages and their harmonics, even with an oversized double-section filter, and the device was affected by transients in the a-c supply. Accordingly, several electronically operated voltage-stabilizing circuits were investigated and a satisfactory circuit developed. The circuit as finally evolved was an adaptation of the

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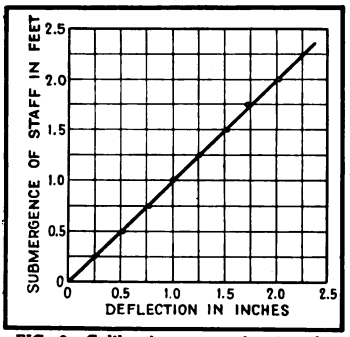

FIG. 3—Calibration curve showing deflection in inches on the screen of an oscillograph versus submergence of a wave-height measuring staff in feet

voltage stabilizer controlled by a thermionic pentode described by Evans[1], operated in conjunction with a gaseous voltage regulator tube rated at 90 volts. The complete circuit is shown in Fig. 4. This circuit provides an output voltage of extreme stability, completely protected from a-c transients and long-time surges. The resulting straight trace on the oscillogram is indistinguishable from a d-c battery trace even when the equipment is operating at full sensitivity. As a matter of fact, the calibrations obtained with this device have been found to be so consistent that it is now necessary to calibrate the resistance staffs themselves only at more or less infrequent intervals; for this reason an artificial calibrating arrangement has been added to the equipment in order to facilitate setting and checking galvanometer sensitivity for waves of various heights.

A block diagram of the complete wave-height measuring apparatus is shown in Fig. 5. All of the component parts described in the paragraph above are contained in a single chassis assembly, the only external connections being the input lead from the resistance staff, the output lead to the oscillograph, and the connection to the a-c line. For use on a wave-action model, as many of these assemblies as may be required, depending on the number of points of wave-height measurement to be recorded simultaneously, are placed in a rack at the point of recording. A group of five of these devices so assembled is pictured in Fig. 6. Oscillographic recording is employed because of the short wave period (1 to 3 sec) of the model waves encountered. For waves of a longer period a recording meter could be connected in place of the oscillograph with equivalent results.

Water-level variations ranging from 10 feet down to less than 0.01 foot have been measured with various physical versions of the wave-height measuring device, and no difficulty is foreseen in extending this range in either direction. The staff can be made of sufficient length to extend below the trough and above the crest of the maximum wave to be measured, and the cross-section may be as large as is necessary to secure the desired rigidity. A three-foot resistance staff has been operated in the Experiment Station lake for experimental purposes. In this installation, a recording milliammeter was employed, together with a system of relays to control the interval and length of records taken. This relay circuit was interconnected with two trigger elements mounted on either side of the resistance staff in order that storm waves not in coincidence with the set intervals of wave recording would not be missed, with the intervals between recordings being successively reduced as the heights of the waves exceeded the values for which the triggers were set.

Prototype applications of this device in lakes or even the ocean

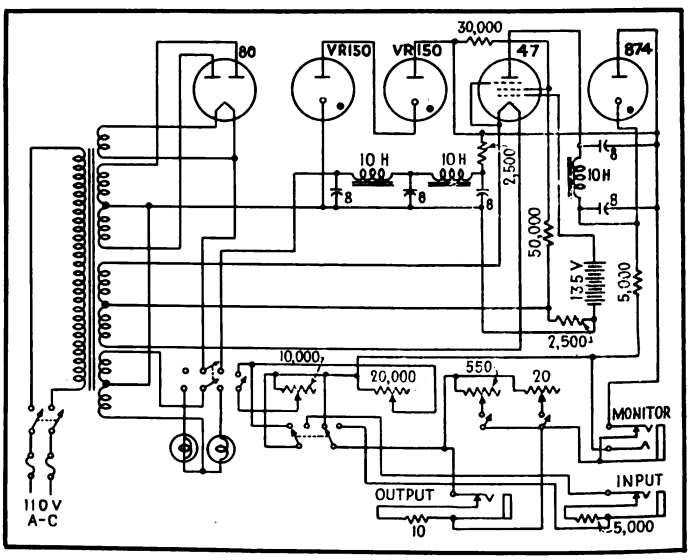

FIG. 4—Voltage-stabilized power supply used in conjunction with wave-height measuring equipment. Provision for setting and checking galvanometer sensitivity is included in this circuit to insure maintenance of calibration

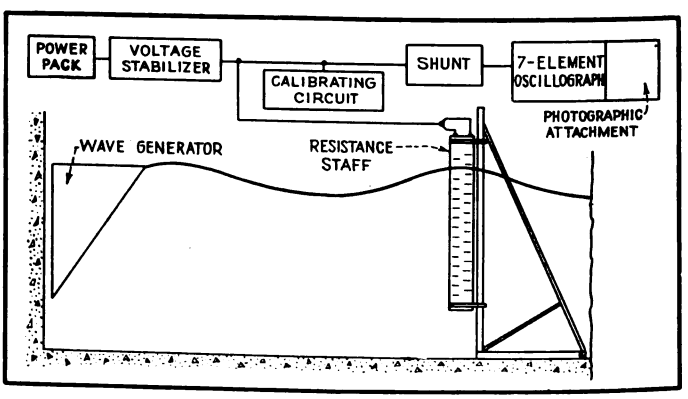

FIG. 5—Block diagram of the complete wave-height measuring apparatus

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have been given consideration. The staff could be attached to an existing nonfloating structure such as a fixed channel marker or a breakwater, or to a substantial pile or pile clump driven at the desired location, while if excessive depth precluded erection of a fixed structure on which to mount the staff an appropriately anchored floating rig would suffice. Wave-height measurements from these installations could easily be relayed by radio to recording meters located on shore or elsewhere. It is believed that the resistance staff can be adapted readily to the measurement and recording of full-size waves.

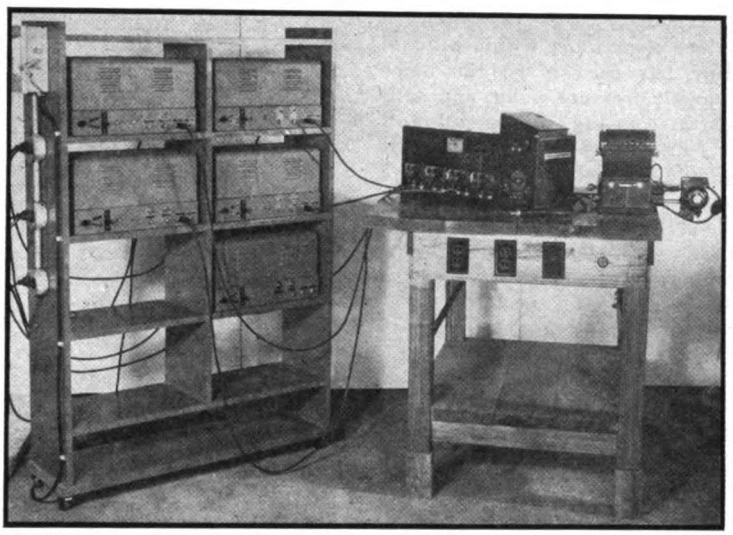

FIG. 6—Five wave-height measuring units may be seen in the portable rack, with an oscillograph at the right

Determining Wave Pressure

Eight pressure cells were supplied by a commercial firm in accordance with specifications. The simplest single-channel setup includes a pressure cell, an attenuator, a one-stage amplifier, a rectifier and filter, an oscillator, and a power supply. These components constitute a modulated a-c bridge as shown in Fig. 7.

The pressure cells or gage heads have a range of 0 to 1 psi when in their most sensitive adjustment. This range may be attenuated in the amplifier input circuit to a range of 0 to 8 psi. The pressure cell is approximately two inches in diameter and four inches long, and consists of three essential parts: the diaphragm, the cell body, and the coil holder. Construction is shown in Fig. 8. The diaphragm, fastened to the gage body, carries an armature which transforms the diaphragm movements caused by pressure into changes of reactance of the coil. A second coil in the unit, known as the balancing unit, remains at a constant reactance, at a value determined by adjustments made during calibration. The two coils are so interconnected in the a-c bridge arrangement that any movement of the armature due to pressure will cause a voltage change in the amplifier input circuit. The a-c voltage is amplified, rectified, and filtered. The final result is a direct-current output proportional to the applied pressure. By connecting a recording oscillograph to the output, dynamic records of water pressures under any desired conditions of operation are obtained.

The pressure cells just described were secured originally for the study of wave force against breakwaters, in which it was necessary to determine the pressures exerted by the waves at various elevations in order to develop vertical pressure curves for use in future design problems. Figure 9 shows a special model breakwater section equipped with pressure cells and wave-height measuring contacts. The cells were soon found to be ideally suited to other applications. One of the more interesting was in the study of pressures due to water hammer in a model of the Fort Peck Dam power tunnel.

Pressure cell equipment has been successfully adapted to supply another long-needed apparatus —a device for recording rapid fluctuations of pressure in hydraulic systems in which conditions do not permit installation of a cell at the point of measurement. An instrument for measuring instantaneous

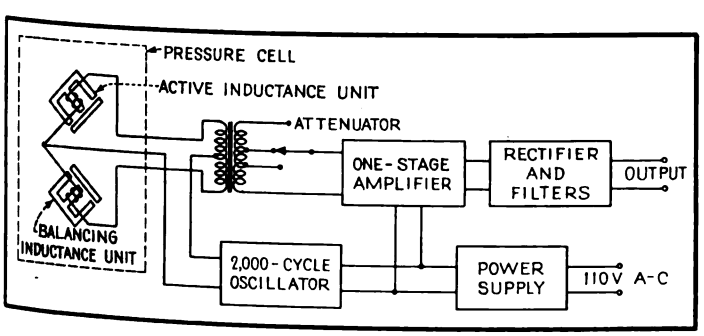

FIG. 7—Block diagram of a-c bridge circuit used to determine wave pressure exerted against model breakwaters, dams and other marine structures. The two inductance units shown within the dashed lines constitute the pressure cell shown in Fig. 8

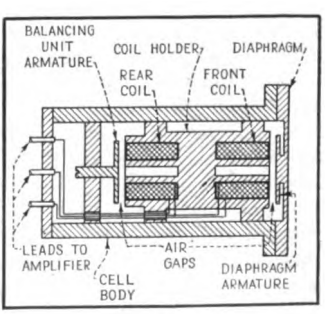

FIG. 8—Gage head or cell employed in the determination of wave pressure. Two such cells may be seen in the photograph of Fig. 9

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values of pressure within a liquid body has been given the name dynamic pressure meter, and is illustrated in Fig. 10. Operation of this device depends upon the hydraulic principle that the pressure impulse at the small opening in the probe will be transmitted practically undiminished through the confined liquid to the face of the pressure cell. The device is sensitive to the rapid pressure fluctuations long known to exist in pump intakes and around baffle blocks below dams. Such measurements have been impossible to secure with the open-well piezometers

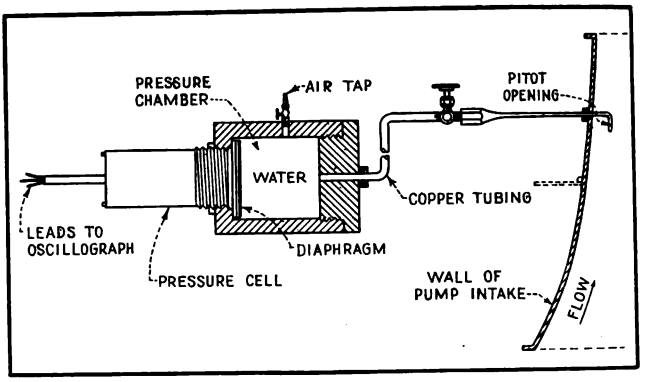

FIG. 10—Method employed to record rapid fluctuations of pressure in hydraulic systems, using one of the pressure cells designed to measure wave pressures. This particular device is called a dynamic pressure meter

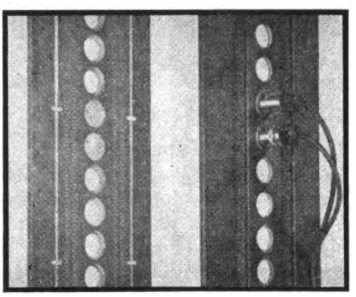

FIG. 9—Model breakwater section equipped with cells such as the one illustrated in Fig. 8 for the measurement of wave pressure, and contacts such as those illustrated in Fig. 1 and Fig. 2 for the determination of wave height

previously employed due to their inherent unresponsiveness to rapid pressure fluctuations. The dynamic pressure meter has been adapted to a wide range of uses involving measurements of both dynamic and static pressures.

Recording Earth Pressures

The pressure cells described are only one of several types employed. Various applications, both for model work and in the field, have involved the use of many of the well-known pressure-responsive elements such as Goldbeck cells, Carlson stress meters, and SR-4 resistance strain gage cells. The principal activities of the Experiment Station have been in the development of cells utilizing resistance-wire strain gages and associated electronic equipment. This equipment has been used for studying settlement pressures in earth-filled dams, for pressure distribution studies in connection with airport pavement design, for field measurements of penstock water-hammer pressures, and for other similar applications. Both direct-current (direct coupled) and alternating-current types of amplifiers have been developed for use in connection with these pressure cells.

Figure 11 shows a typical field installation for dynamic measurement of earth pressures, in which six direct-current amplifiers were employed. In this application it was considered necessary to use direct-current amplifiers due to the high-frequency shock pressures to be recorded. The circuit for these amplifiers was based on the circuit described by Trevino and Offner[2]. For other applications it has been possible to use alternating-current amplifiers, and a more or less standard circuit has been developed for this equipment, which includes a 2000-cycle oscillator to supply bridge voltage, a three-stage amplifier, rectifier, and filters. A block diagram of this equipment is presented in Fig. 12.

Pressure cells for hydrostatic measurements are somewhat simpler in construction than the earth pressure cells, and this type of cell will therefore be described first. The basic element employed in these devices is the SR-4 resistance wire strain gage, which consists of a grid of very fine resistance wire assembled on a thin layer of paper, with suitable protective felt covering. In practice this gage is cemented to a metal diaphragm and functions by virtue of the fact that strain in the diaphragm resulting from bending due to applied pressure will result in strain in the wire grid sufficient to pro-

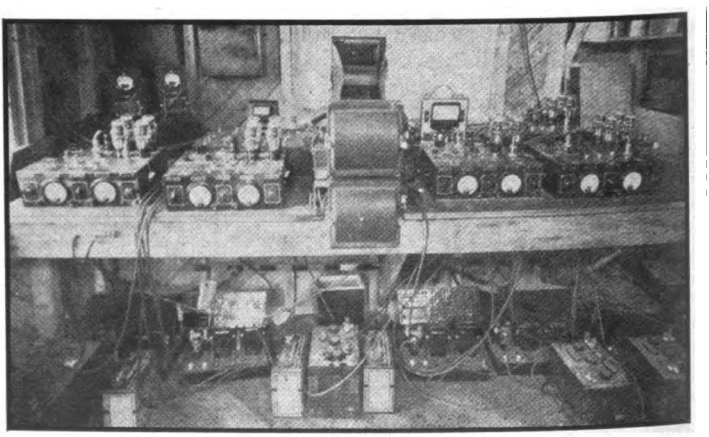

FIG. 11—Field installation of resistance-wire strain gage equipment designed to measure earth pressures. One of its uses was in connection with the design of bombproof shelters. In this instance d-c amplifiers were used

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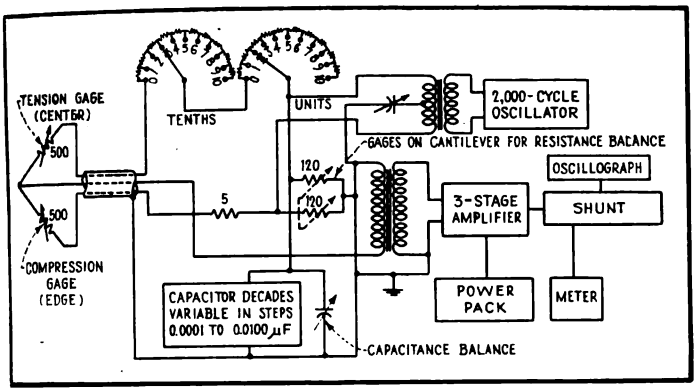

FIG. 12—Block diagram of a-c bridge circuit used in conjunction with resistance-wire strain gages for the measurement of earth pressures

duce a change in the resistance of the wire. It is this change in resistance, previously correlated with pressure applied to the diaphragm, which provides a measure of the pressures under observation. Temperature compensation is secured by mounting a second strain gage on a portion of the cell not subject to strain, or in some cases so mounted on the edge of the diaphragm that compression occurs as pressure is applied. In either case, this compensating gage is connected in an arm of the input bridge in opposition to the tension gage as shown in Fig. 12, which results in cancellation of strain changes in the material due to temperature variations.

Constructional details of the hydrostatic cell are shown in Fig. 13. Note the active gage mounted on the machined diaphragm, the temperature-compensating gage mounted on a metal shelf above it (not subject to strain due to pressure), and the three-conductor cable brought out of the rear of the cell through a water-tight packing nut. The face of the cell is covered by a sand screen to exclude earth from intimate contact with the cell diaphragm in cases where the cell is installed in earth dams for measurement of pore pressures. Other applications of this cell have included investigation of micro-turbulence and macro-turbulence on the bed of the Mississippi River.

The earth pressure cell differs from the hydrostatic cell in that pressure does not act directly on the diaphragm. In this type of cell the pressure is applied to a machined faceplate which is connected to the cell body through a flexural ring milled in its periphery. The space between the face plate and the diaphragm is filled with transformer oil under low pressure. This construction insures that any uneven pressure applied to the faceplate will be uniformly applied to the diaphragm.

The six-channel amplifier shown in Fig. 14 is typical of the electronic equipment provided for use with pressure cells or other de-

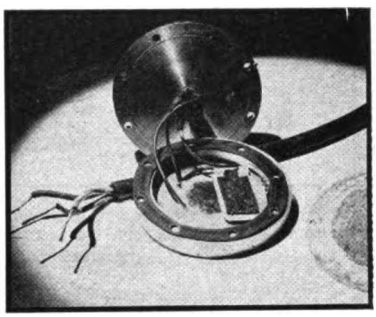

FIG. 13—Photo showing constructional details of a hydrostatic pressure cell. The active resistance-wire strain gage element is mounted on a machined diaphragm subject to flexure by pressure, while a temperature-compensating gage element is mounted on a shelf which is not subject to such flexure

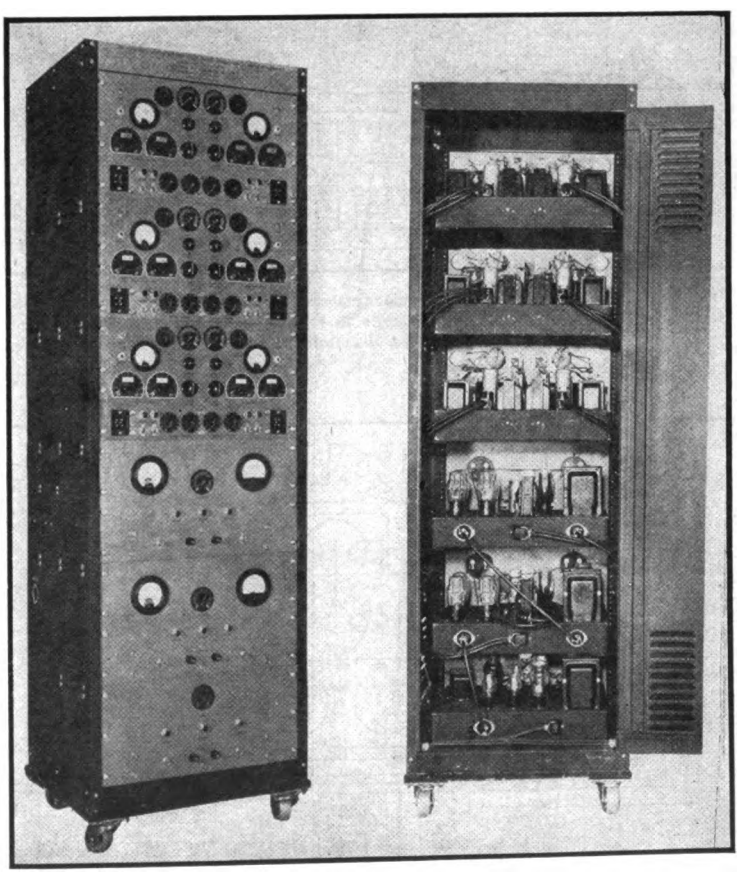

FIG. 14—Two views of a six-channel amplifier used in conjunction with pressure cells or other devices containing resistance-wire strain gages

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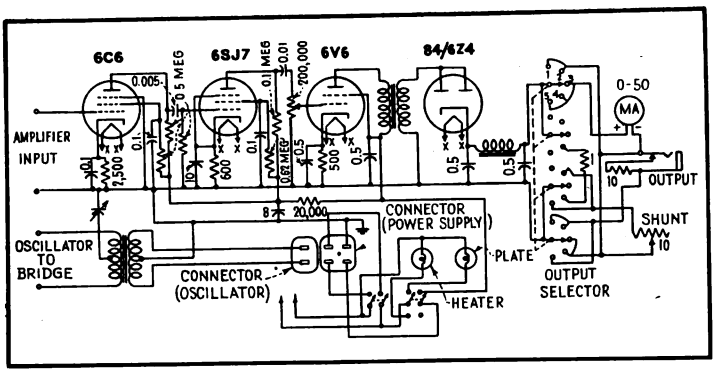

FIG. 15—Circuit of three-stage amplifier employed in the unit pictured in Fig. 14. It is used in conjunction with the oscillator shown schematically in Fig. 16 and the power supply shown in Fig. 17

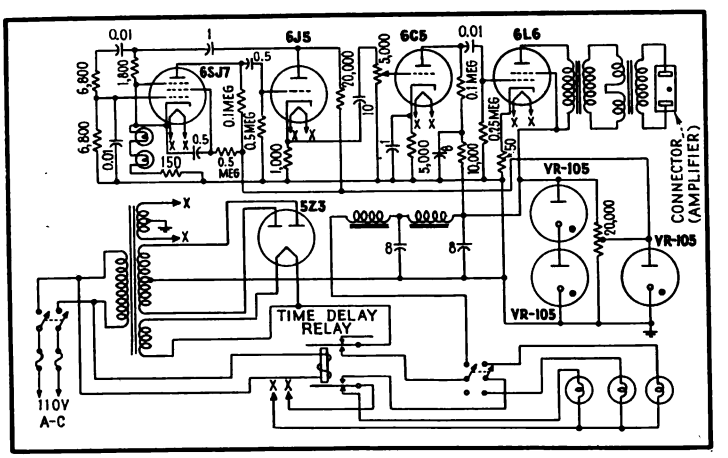

FIG. 16—Resistance-controlled 2000-cycle oscillator used in combination with amplifiers such as the one shown schematically in Fig. 15. It supplies power to six a-c bridges, the output of which drives associated amplifiers and oscillographs

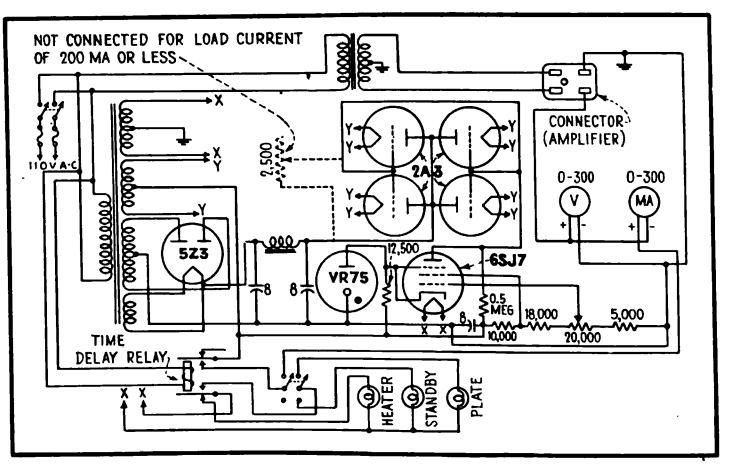

FIG. 17—Electronically-stabilized power supply used with amplifiers such as the one shown in Fig. 15

vices containing resistance strain gages as the measuring element. The detailed circuit for a typical three-stage amplifier is presented in Fig. 15, including the rectifier, filter, and output selector connections. The 2000-cycle oscillator diagram is shown in Fig. 16. A resistance-controlled circuit was selected for stability. The buffer stage serves to divorce the oscillating circuit from load changes, and the power stage supplies the necessary output for operating six bridge circuits. The electronically regulated power supply is shown in Fig. 17. This circuit provides a constant plate voltage for each amplifier channel, unaffected by line transients or load changes.

In operating the equipment, each input circuit is brought to a resistive and capacitive balance and the oscillator voltage, individual channel gain, and output shunt are adjusted for the desired attenuation as determined by the resistance change expected. Calibration, in terms of resistance change, is then accomplished by means of the decade resistance units incorporated in the input circuit.

The particular equipment just described was designed for use on airport pavement tests for determining pressure distribution in the subgrade and for measuring pavement deflections. For the former measurements the earth pressure cell is used, while for the latter measurement a special deflection gage has been developed. This device employs the SR-4 gage as the measuring element, but in this case strain is produced in the gage by movement of a cantilever arm on which the gage is mounted. Movement of the cantilever arm is produced by a tapered pin which is displaced as the pavement deflects under load. Constructional details of this gage are shown in Fig. 18. This gage is installed in the surface of the pavement as shown in Fig. 19.

Both the pressure cells and deflection gages employing the resistance strain gages have a linear characteristic over their operating range. Figure 20 is a calibration curve for a deflection gage with a 0.3-inch range. This curve was obtained by making incremental offsets on the gage and com-

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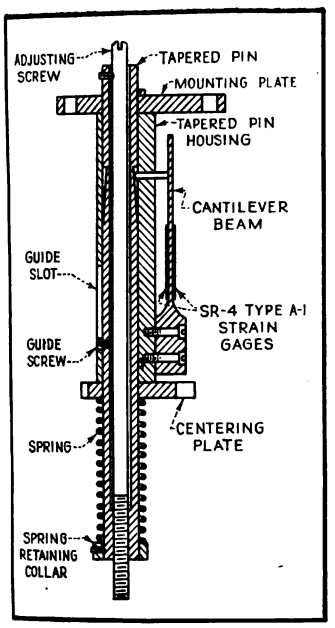

FIG. 18—Details of a gage used to measure pavement deflections

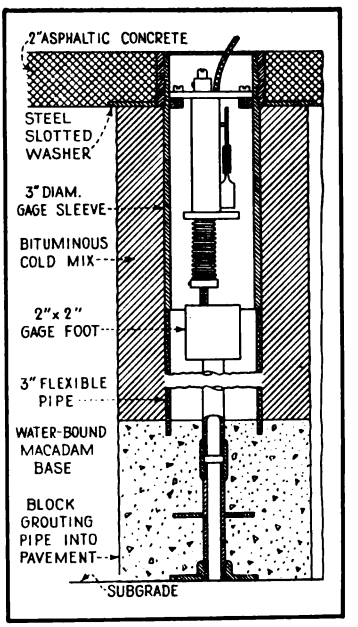

FIG. 19—Method of installing the gage illustrated in Fig. 18 in pavement

puting resistance changes from readings required to balance a special Wheatstone bridge designed for use with these gages. In operation, the amplifier is calibrated as previously explained by recording 0.1-ohm resistance changes on the oscillogram. This calibration is then used in conjunction with the gage factor stated on the calibration curve as a means of interpreting the deflection records obtained during load passages over the pavement. The oscillogram in Fig. 21(A) illustrates the calibration method just described, while the oscillogram in Fig. 21(B) shows a typical record obtained from pressure cells installed in an airport pavement test.

Other Electronic Applications

Circuits involving thyratron tubes have been developed for a number of applications. For example, on all models involving the simulation of tidal action, a rather complicated cam-operated apparatus has been developed for automatic and continuous reproduction of the tidal cycle. Irregularities in operation of this equipment were traced to floating control contacts, at which point inevitable surface corrosion film was causing erratic closing of control relays. Insertion of a thyratron-operated booster relay in the floating contact circuit has completely alleviated this difficulty.

A typical booster-relay thyratron circuit as employed on tide-control equipment is shown in Fig. 22. The grounding polarity light is incorporated as a ready means of determining proper polarity in plugging in the equip-

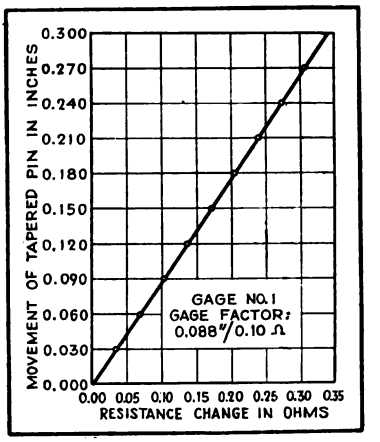

FIG. 20 — Deflection-gage movement versus resistance change in ohms

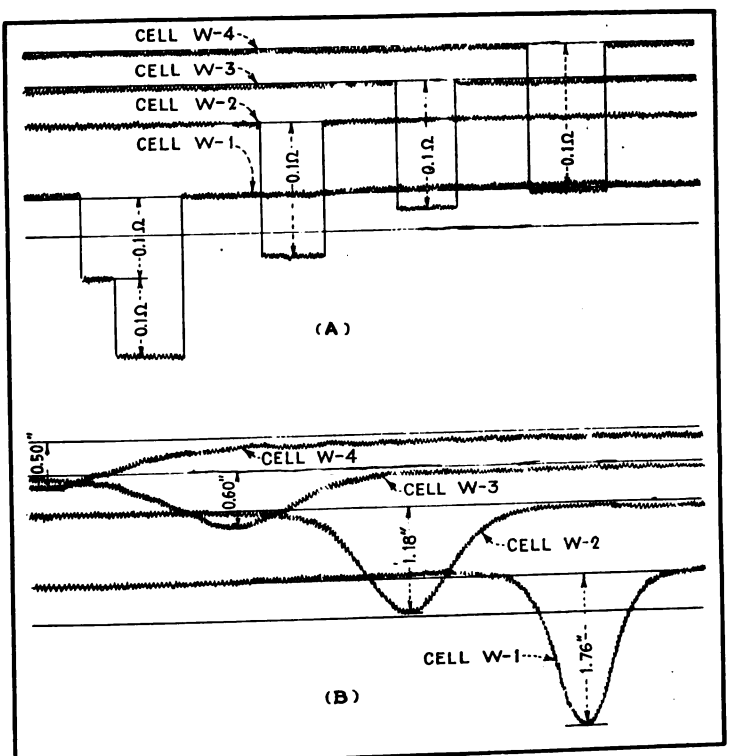

FIG. 21—(a) Oscillogram illustrating the method of calibrating a deflection gage explained in the text. (b) Typical record obtained from a deflection gage installed in the pavement of an airport runway

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ment, which is frequently moved about, since proper and foolproof grounding of the equipment is considered essential due to its customary use in proximity to bodies of water. The transformer, rectifier, and filter provide a steadier operating condition for the thyratrons than could be obtained with straight a-c operation, and were incorporated for this reason. The indicating lights were included as a visual aid to the operator during adjustment of the tidal apparatus.

Another thyratron-controlled relay circuit has been developed for timing the passage of floats between fixed points in model discharge ranges and has proved to be much more accurate than previous manual timing methods. The problem here was to start a stop-watch as a float passed under a wire at a certain point and to stop the watch as the float passed another wire, say 12 inches downstream from the first wire. This is accomplished in the circuit shown in Fig. 23.

Passage of a metallic float under a cat-whisker wire produces a momentary high-resistance contact sufficient to fire the thyratron tube and its associated relay. This operation starts the electric stop watch, locks out the relay circuit for a fraction of a second to prevent any effects from bouncing of the float on the initial contact, and then sets up the relay circuit to drop out on the next contact. Passage of the float under the second cat-whisker wire results in stopping of the stop-watch, temporary locking out of the relay circuit as explained above, and then restoration of the relay circuit to the starting condition. This circuit makes it necessary to use only one lead wire from the contacting frame to the thyratron circuit, which enables the operator to make a very sensitive adjustment of the operating point.

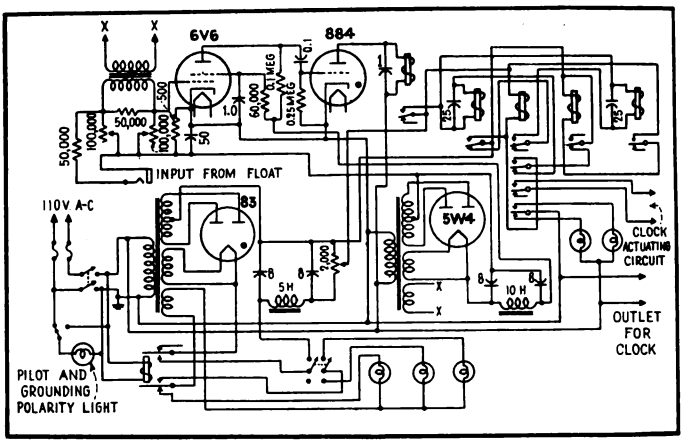

FIG. 23—Electronic circuit used to time the passage of a metallic float down a model waterway. The float contacts a wire as it passes the starting point and a clock is started. It then contacts another wire farther downstream and the clock is stopped

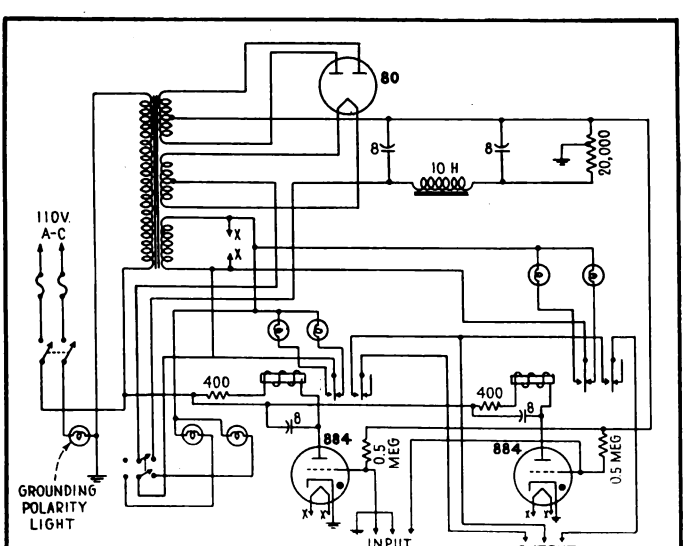

FIG. 22—Thyratron booster circuit employed in studies of tidal cycles. It avoids irregularities of operation formerly caused by corrosion of contacts mounted on floating supports and insures proper control relay operation

Electronic devices are meeting the instrumentation requirements of the Experiment Station by means of the apparatus described above and in many other ways. Much work has been done in connection with model photography, including timed flashes for velocity measurements by means of timed floats, and in the timing of photographic processes. Salt-water studies have required the development of conductivity apparatus, and a soil moisture content and temperature investigation has required other special equipment. New developments and applications are continuously under way in the Electrical Measurements Laboratory.

The Waterways Experiment Station operates under the supervision of the President, Mississippi River Commission, which is a direct agency of the Office of the Chief of Engineers. Brigadier General Max C. Tyler is President, Mississippi River Commission, while activities of the Experiment Station are directed by Gerard H. Matthes, Head Engineer.

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(1) Evans, Robley D., Voltage Stabilizer Controlled by a Thermionic Pentode, *Rev. Sci. Inst.*, 5, 371, Oct. 1934.

(2) Trevino, S. N., and Offner, Franklin, An A-C Operated D-C Amplifier with Large Current Output, *Rev. Sci. Inst.*, 11, p. 412, Dec. 1940.

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INTERFERENCE IN F-M RECEIVERS

Review of equations covering interference-suppressing ability when desired and undesired signals have the same average frequency, with experimental verification by measurements on a representative commercial receiver

By ROBERT N. JOHNSON
Collingswood, N. J.

THERE has been developed a theory by Reich[1], Pollack[2], and several others concerning the ratio of interference to desired signal in the audio output of an idealized frequency-modulation receiver for known ratios of interfering to desired input signals. The object of this investigation was to determine whether or not an average commercial frequency-modulation receiver adheres to this theory regarding interference.

The type of interference which was studied and applied in measuring the suppression ability of the receiver under test was that which results from two signals having the same average frequency, one being considered as the desired signal and the other as an interfering signal. The conditions chosen represent an interference problem at its worst.

Theory of Single-Channel Interference

For convenience, consider the desired signal to be of unit amplitude, and the interfering signal to be of amplitude a. It is assumed that if a were comparable to "unity," the interference would be so great that no one would attempt to listen to the desired signal. Consequently, this case has little practical interest. However, when the desired signal is at a modulation lull, the interfering signal, even though relatively small in magnitude, produces an undesirable psychological effect, since it can now be heard together with the desired audio output. It is under these general conditions that the interference suppression of a commercial receiver was studied.

A term which occurs quite frequently in the analysis of single-channel interference is instantaneous frequency. Assuming a voltage of the form $e = A \cos \phi$, a customary and suitable definition of instantaneous frequency is $\omega = d\phi/dt$, where ω is the instantaneous angular frequency and $d\phi/dt$ represents the rate of change of the angular displacement with respect to time.[3] It is this definition that will be used.

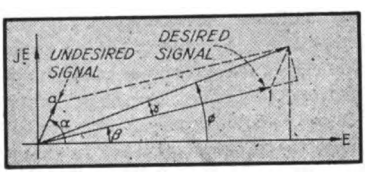

FIG. 1—Vector diagram for desired and undesired f-m signals, both having the same frequency

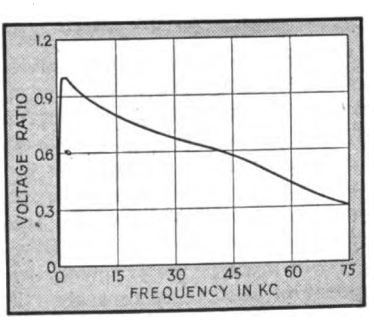

FIG. 2—Frequency response of output system into which audio system of f-m receiver was fed for visual indication of interference wave form

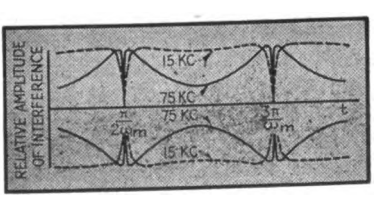

FIG. 3—Calculated interference pattern envelopes for deviations of 15 and 75 kc

The desired signal is not modulated, the condition of a modulation lull being assumed; only the carrier is present. The undesired signal is frequency-modulated with a frequency deviation of $\pm\overline{\Delta\omega}$ and at a modulation frequency of ω_m which is much less than the carrier frequency.

Referring to Fig. 1, the desired and undesired signals at some instant of time are respectively 1 cos β and a cos α. The following expressions may be written

$$\frac{d\beta}{dt} = \omega_0 = \text{constant carrier frequency} \quad (1)$$

$$\beta = \int \omega_0 \, dt = \omega_0 t + \theta \quad (2)$$

$$\frac{d\alpha}{dt} = \omega'(t) = \omega_0 + \overline{\Delta\omega} \cos(\omega_m t) \quad (3)$$

which represents the frequency variations of a frequency-modulated signal. Then

$$\alpha = \int \omega'(t) dt = \left[\omega_0 t + \frac{\overline{\Delta\omega}}{\omega_m} \sin(\omega_m t + \theta) \right] \quad (4)$$

The output of a frequency-modulation receiver should be proportional to the instantaneous frequency of the input signal. In the present case, the instantaneous frequency resulting from the superposition of two input signals is to be determined. Referring to Fig. 1 again, the instantaneous frequency of the resultant signal is seen to be $\omega = d\phi/dt$. The problem, therefore,

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is to solve for the value of ω.

It can be seen by inspection that $\phi = \beta + \gamma$. Now by simple trigonometric relationships we can write

$$\gamma = \tan^{-1} \frac{a \sin (\alpha - \beta)}{1 + a \cos (\alpha - \beta)} \qquad (5)$$

or, since a is much less than unity

$$\gamma \cong a \sin (\alpha - \beta) = a \sin \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right] \qquad (6$$

Then

$$\phi = \beta + a \sin \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right] \qquad (7)$$

By definition

$$\omega = \frac{d\phi}{dt} = \omega_0 +$$

$$[a \overline{\Delta\omega} \cos (\omega_m t)] \cos \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right] \qquad (8)$$

where

ω = resultant instantaneous angular frequency of input signals
a = magnitude of undesired signal, equal to the ratio of interfering to desired input signals since the desired signal is of unit amplitude
$\overline{\Delta\omega}$ = maximum angular frequency deviation of interfering signal
ω_m = angular frequency of modulation of interfering signal
t = time in seconds

Analysis of Discriminator Output

The resultant instantaneous angular frequency as given by Eq. (8) is seen to be composed of both a constant and a varying term. In a frequency-modulation receiver, the output of the discriminator is proportional to the variations in the instantaneous angular frequency. Consequently, the varying term of Eq. (8) is important in this analysis. It is equivalent to a sinusoidal variation with magnitude $[a \overline{\Delta\omega} \cos (\omega_m t)]$ and frequency d/dt $[(\overline{\Delta\omega}/\omega_m) \sin (\omega_m t)]$ $= \overline{\Delta\omega} \cos (\omega_m t)$, with both the magnitude and the frequency varying sinusoidally with time. This varying frequency will be defined as the interference frequency and will be denoted by the symbol f_{int}. Thus, $f_{int} = [\Delta\omega \cos (\omega_m t)]/2\pi$.

Considering Eq. (8) once again, the resultant instantaneous angular frequency varies sinusoidally in magnitude about the mean carrier frequency ω_0. These variations are from ω_0 to $\omega_0 + a \overline{\Delta\omega}$ and back to ω_0 for half a period of the modulating wave. At any particular instant of time, deviation of the resultant instantaneous angular frequency is occurring at a definite frequency which is the interference frequency. Thus we have a frequency (the resultant instantaneous angular frequency) varying sinusoidally in magnitude at some other frequency (the angular modulation frequency). Also, when viewed at successive instants of time, these variations are in themselves varying sinusoidally at still another frequency, the interference frequency.

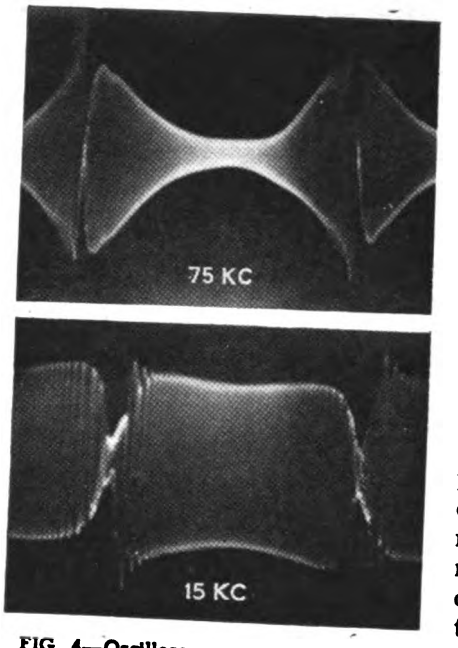

FIG. 4—Oscilloscope patterns obtained under same conditions as represented by Fig. 3

Allowances for Deemphasis

The results thus far have given us, theoretically, the wave form of the interference in the output of a frequency-modulation receiver, since in this type of receiver the audio output is proportional to the variations in instantaneous frequency as given in Eq. (8). However, in practice the frequency response of the receiving system is not flat. This is due to the frequency limitations of the audio system and to the standard deemphasis circuit placed at the output of the discriminator to restore the modulation to what it was before standard RMA preemphasis at the transmitter. This preemphasis of the higher-frequency components is proportional to $\sqrt{1 + (\tau\omega_1)^2}$, where τ is the standard 100-microsecond time constant and ω_1 is the angular frequency. The reciprocal of this proport... ...ty factor is effected in the receiver by the deempl... ...cuit. Consequently, the ... ...ence in the audio output is proportional to

$$\frac{[a \overline{\Delta\omega} \cos (\omega_m t)]}{\sqrt{1 + (\tau\omega_1)^2}} \cos \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right]$$

$$\frac{a\, 2\pi f_{int}}{\sqrt{1 + (\tau\, 2\pi f_{int})^2}} \cos \left[\frac{\overline{\Delta\omega}}{\omega_m} \sin (\omega_m t) \right]$$

The ratio of interference ... ...sired signal in the output ... ...receiver as considered in t... ...alysis is N/S, where N is p... ...plitude of interference in ... ...output of f-m receiver due t... ...position of a small, undesir... ...quency-modulated signal on ... ...modulated desired signal, b... ...nals being of the same aver... ...quency, and S is peak ampl... ...the desired signal alone, fr... ...modulated, in audio output ... ...receiver.

The problem is to determ... ...for various ratios of input ... The ratio of input signals ... ...by a since the desired signa... ...sidered to be of unit ampli... this analysis, the standard ... ...mum frequency deviation ... ...kc is assumed to correspond ... ...full permissible range of a ... ...lating signal at the input ... ...system. It follows that th... ...tional utilization of this full ... ...by the interfering signal ... audio output is

$$\frac{a\, 2\pi f_{int}}{2\pi \times 75{,}000 \sqrt{1 + (\tau\, 2\pi f_{int})^2}}$$

Thus the ratio of interfere... ...desired signal in the output ... ...be written as

$$\frac{N}{S} = \frac{a f_{int}}{75{,}000 \sqrt{1 + (\tau\, 2\pi f_{int})^2}}$$

or, if $(\tau\, 2\pi\, f_{int})^2$ is much l... ...than unity, the above expressi... ...comes

$$\frac{N}{S} = \frac{a}{2\pi \times 75{,}000\tau} = \frac{a}{\tau\, \Delta\omega}$$

For $\tau = 100$ μsec, this reduc... $N/S = a/47$.

Practical Considerations

For input signal sources two ... ...nal generators were employed, ...of which could be frequency-m... ...lated. These were connected to ... input terminals of the comm... ...cial frequency-modulation rece... under test. This particular rece... included a deemphasis circuit ...

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not an audio amplifier. The audio output of the receiver was fed into the output system, which consisted of the following units given in the order of connection to the receiver: (1) a calibrated voltage-dividing network; (2) a high-gain voltage amplifier; (3) a high-pass filter circuit; (4) an oscilloscope.

The voltage-dividing network was used to produce an equal deflection on the oscilloscope screen for the cases of interference and desired signal respectively in the audio output of the receiver. It was thus possible to determine N/S for various prescribed input conditions. Because of the small magnitude of the interference voltage it was necessary to provide the high-gain voltage amplifier. Also, because of the small magnitude of the interference voltage, hum pickup of supply power frequencies and harmonics thereof became objectionable. The high-pass filter was inserted to eliminate this trouble. The oscilloscope was used to give a visual indication of the interference wave form and also as an indicator of its peak amplitude.

The over-all frequency response of the output system is given in Fig. 2. This includes the amplifying circuits of the oscilloscope. The effect of the filter circuit in cutting off the lower frequencies is evident. The linear frequency scale was used to give direct comparison with the cathode-ray oscilloscope patterns.

For the particular receiver tested, the over-all time constant, corresponding to that which occurs in the analysis, was measured and found to be 80 microseconds.

In calculating the envelope of the interference pattern so that it may be compared with the experimental pattern as seen on the screen of the oscilloscope, the attenuation effect of the output system with respect to frequency is just as important as the attenuating effect of the deemphasis circuit in the receiver. Consequently, the envelope of the calculated interference pattern is proportional to the magnitude of Eq. (9) multiplied by the frequency response curve of the output system.

Since the interference frequency has a maximum value equal to the frequency deviation, the shape of the interference pattern envelope depends on the deviation. This envelope has been plotted for the two representative deviations of 75 and 15 kc and for the measured time constant of 80 microseconds in both cases. These plots are given in Fig. 3.

Photographs of the experimentally obtained patterns for the same two deviations and time constant are shown in Fig. 4. In these photographs, it is possible to see the actual variation in the interference frequency. This variation is sinusoidal and is represented by the changing density of the lines crossing the horizontal axis. It can be seen that the portion of the pattern having the greater density of lines is of a lower amplitude. This is consistent with the attenuating effects of the output system and the deemphasis circuit. To correlate the effects of the various attenuating factors on the interference pattern envelope, Fig. 5 is included.

Conclusions

The quantitative results are given in Fig. 6. Before the significance of the results is discussed, it might be well to elaborate on how the theoretical line, which indicates N/S as a function of a, is obtained. The theoretical line is obtained from Eq. (10) using the measured value of time constant equal to 80 microseconds. The value of interference frequency used was obtained graphically from the calculated interference pattern envelope for the 75-kc deviation. The interference frequency corresponding to the maximum point in the envelope was used in the calculations.

The measured and theoretical results deviate somewhat for increasing values of a. This is justified by the basic assumption that a is considered to be much less than unity.

The variations in measured results for different values of desired input signal are probably attributable to a slight error in the decade attenuation box on the f-m signal generator used. For small values of a, where the theoretical line is more accurate, these variations are of little importance.

In conclusion, the significant result of this investigation is that calculations relative to interference made on the basis of an idealized frequency-modulation receiver have been applicable to a representative commercial receiver.

This article is based on a bachelor's thesis submitted to the Department of Electrical Engineering of Massachusetts Institute of Technology. The author wishes to acknowledge the generous assistance of Professor L. B. Arguimbau, who supervised the thesis.

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(2) Pollack, Dale, M.I.T. E.E. Doctorate Thesis, 1940.
(3) Brainard, J. G., "Ultra-High Frequency Techniques," D. Van Nostrand, New York, 1942, p. 233.

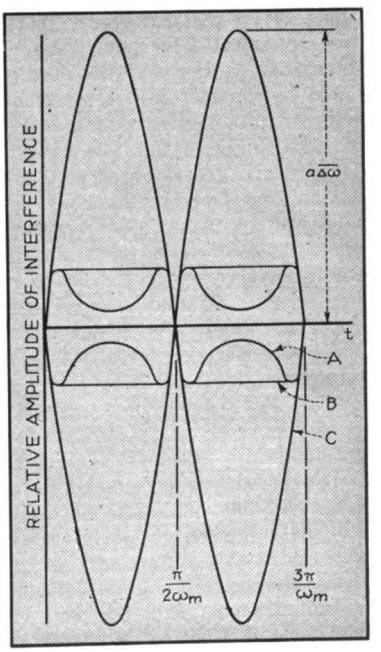

FIG. 5—Interference pattern envelopes for various attenuating factors. A—deemphasis circuit and output system; B—deemphasis circuit alone; C—theoretical envelope for no attenuating factors

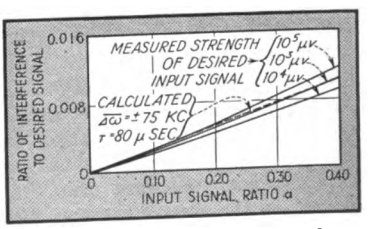

FIG. 6—Ratio of interfering signal to desired signal in the audio output of a representative f-m receiver, plotted as a function of the input signal ratio

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Restorer-Circuit

Qualitative explanation of the operation of the direct-current restorer circuit used in television receivers and related instruments to maintain constant brightness. The circuit shifts all incoming signals to the same direct voltage reference level

THE D-C RESTORER CIRCUIT makes the voltage applied to the grid of a tube start from a predetermined level, usually the cut-off potential of the tube. In television, this circuit alters the bias level of the tube so that signals to be reproduced on the cathode-ray tube are restored to the same relative intensities as those at the studio.

Let us consider a direct-current restorer circuit with values as indicated in Fig. 1(a). We have a square-wave generator of zero internal impedance, delivering an input voltage that varies from zero to + 100 volts at a frequency of 100 cycles per second as shown in Fig. 1(b). We shall also assume that the diode has about 1000 ohms of resistance during conduction.

Negative Restorer

During the first half cycle, the generator can be considered as a battery of 100 volts. The 100 volts will instantaneously appear across the resistor because the voltage across the capacitor cannot change instantaneously. Thus the plate of the diode is positive with respect to the cathode and the diode will conduct. The 1000 ohms of the conducting diode in parallel with the one-megohm resistor gives a resultant resistance of about 1000 ohms. The 0.1-μf capacitor charges through 1000 ohms resistance. The time constant of this charging circuit is 100 microseconds.

The time during which the capacitor can charge is the time during which the 100 volts is applied, or the time for a half cycle of the square wave. Because the frequency of the square wave is 100 cycles per second, the time for half a cycle is 5000 microseconds or 50 times the time constant of the R-C charging circuit. Since at the end of a period equal to six time constants we can consider the capacitor fully charged for all practical purposes, we see that the voltage E_c taken from A to B across the capacitor follows the curve indicated in Fig. 1(c). The voltage across the resistor or tube is the applied voltage less the voltage across the capacitor at each instant of time, as indicated in the first half cycle of the Fig. 1 (d).

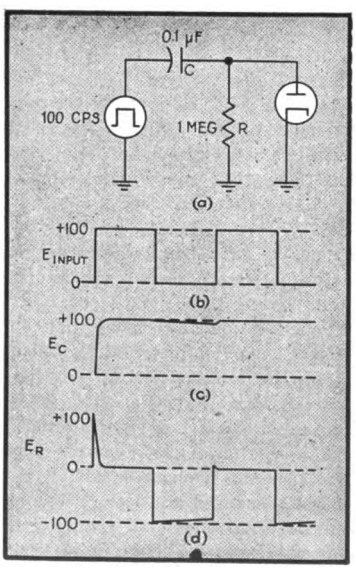

FIG. 1—Diode circuit for negative restoration and voltage wave shapes across various circuit elements

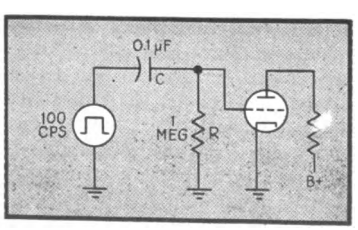

FIG. 2—Triode adaptation of negative restorer circuit

Capacitor Discharge

Because the input voltage from the generator is zero during the next half cycle and can be considered as a short circuit, the capacitor discharges through the one-megohm resistance, the full 100 volts appearing instantaneously across the resistor. The plate of the diode is now negative with respect to the cathode and the diode does not conduct. Thus the capacitor must discharge through the one-megohm resistor, giving a discharge time constant of 100,000 microseconds.

The capacitor will discharge only during the half cycle during which the generator is zero for a time of 5000 microseconds, thus the time available for discharge is 1/20 of a time constant of the discharge circuit. With this amount of time available, the capacitor will discharge a very small amount and the voltage from A to B will be, for the second half cycle, as shown in Fig. 1(c). The voltage across the resistor will be as shown in the second half cycle of Fig. 1(d).

During the first half of the second cycle, we again have +100 volts applied. The capacitor has a charge of almost 100 volts, just a slight positive voltage appears across the tube (E applied minus E_c). This small voltage will cause the tube to conduct, charging the capacitor quickly back up to 100 volts. The voltage across the tube will subsequently drop to zero. The voltage across the capacitor and resistor for this half cycle is shown in Fig. 1(c) and 1(d) (E_c and E_R for the first half of the second cycle).

If we compare the output voltage with the input voltage, we see

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Operation

By EMANUEL LAST

Development Engineer
Munston Mfg. and Service Co.
New York, N. Y.

that the wave shape and peak-to-peak voltage are unchanged, but that the output wave is all below zero or has been restored negatively in that the top of the wave is at zero.

This action is known as negative restoration. If we had taken an a-c square-wave input varying from −50 volts to +50 volts, we would find that our output would also be negatively restored, varying from zero to −100 volts. The difference in operation is that the capacitor charges to 50 volts instead of 100 volts.

The circuit behavior depends upon two facts: first, that the capacitor charged rapidly during the conduction period of the tube; second, that it discharged slowly during its discharging period. Thus the conducting or charging time constant must be very short in comparison with the time for half a cycle, and the non-conducting or discharging time constant must be very long with respect to the time for half a cycle. Under these conditions restoration is completed after one cycle.

Triode Circuit

Using the same circuit, let us substitute a triode for the diode so that the triode grid replaces the plate of the diode and the triode cathode replaces the cathode of the diode, as shown in Fig. 2. Because the grid and cathode of the triode act like a diode, the resulting wave shape between grid and cathode will be the same as obtained before, if we assume that the grid-to-cathode resistance during grid current flow is about 1000 ohms, as was true of the diode. Because this wave varies from zero to 100 volts negative and has equal half cycles, we can consider it as an a-c wave of 50 volts above and below zero, being applied on a bias of −50 volts. In other words, we have developed a grid bias of −50 volts by means of the d-c restorer.

Positive Restorer

Let us examine the circuit of Fig. 3, which differs from the circuit in Fig. 1 in that the diode has been reversed and we are now using a balanced square-wave. During the first half cycle the +50 volts will appear across the tube, making the cathode positive with respect to the plate and resulting in the tube not conducting. The capacitor charging through the one-megohm resistor will charge very little so the wave shapes for the first half cycle are as indicated in Fig. 3(c) and 3(d).

When the voltage reverses in the second half of the first cycle, approximately −50 volts will appear instantaneously across the tube, making the cathode negative with respect to the plate and causing the tube to conduct, quickly charging the capacitor. The voltage across the resistor and capacitor is as shown for the second half of the first cycle in Fig. 3.

At the first half of the second cycle, the generator is delivering +50 volts and the capacitor is charged to 50 volts in a polarity as indicated in Fig. 3. Because the generator and capacitor voltage are additive, the voltage across the resistor will instantaneously be +100 volts. The capacitor will not discharge very much through the long time-constant circuit. Thus the voltage across the capacitor will remain at almost −50 volts and the voltage across the tube will remain at practically +100 volts as shown in Fig. 3(d). During the second half of the second cycle, the generator and capacitor voltage will be in opposition and the voltage across the tube will be the slight difference between the two. The capacitor will again quickly charge to −50 volts through the tube. The wave has been restored in the positive direction so that the lowest part of the wave is at zero and the rest above the zero axis. This circuit is known as a positive d-c restorer.

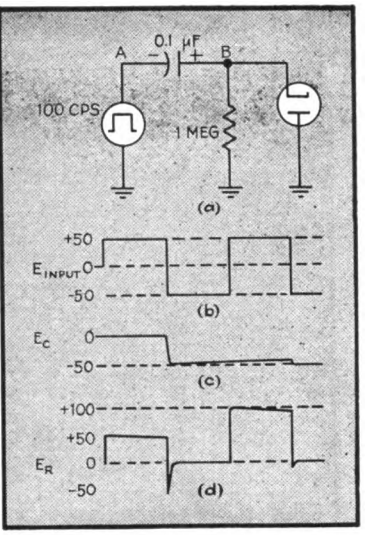

FIG. 3—Positive restorer diode circuit and wave shapes indicate how restoration bias is developed

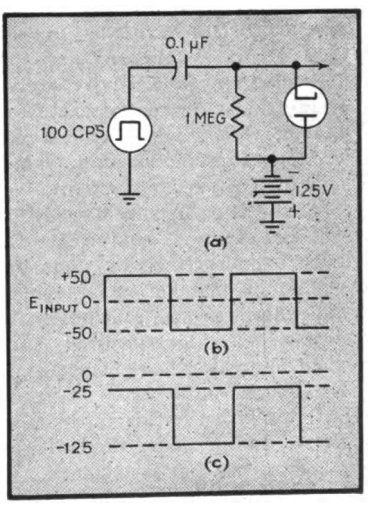

FIG. 4-(a) Biased negative restoration circuit, (b) input wave, and (c) output wave after equilibrium is reached

The circuit in Fig. 4(a) will produce positive restoration above the applied negative potential, as at Fig. 4(c). In this manner reference levels other than zero can be obtained.

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VIBRATIO

Aircraft installation of this typical Collins transmitter requires some means of stopping vibration and shock before it reaches the equipment. Mounting gear of the type shown here is described in the text

DEVELOPMENT TRENDS in electronic equipment are all toward greater sensitivity, lighter weight, and more compactness—each of which tends to make a piece of apparatus increasingly vulnerable to shock and vibration.

At the same time, field conditions for electronic equipment—war uses, applications in industrial plants, or installation in vehicles and carriers, are continually exposing this highly-evolved equipment to greater adversity by vibration and shock.

One solution to this apparent impasse, and perhaps the only one which gives full consideration to the two opposing factors, is the use of devices which, in effect, cut the sensitive equipment loose from the vibrating platform.

Principles and Terminology

In the early stages of the vibration-control art, the typical way of combatting vibration involved the incorporation of structural materials of various kinds.

The designer called upon cork, felt, sponge rubber, or springs to solve his problems without much recourse to anything more than rule-of-thumb specifications. Examples include the early carbon microphone suspension which did what was necessary but with only a small resemblance to the type of mounting that would be considered good design today.

TABLE I—VIBRATION INSULATION

Insulation Ratio	Percent Insulation	Result
10.0	98.9	Excellent
4.0	93.3	Very good
3.0	87.5	Good
2.5	81.1	Fair
2.0	66.7	Useful
1.5	20.0	Poor
1.4	0.0	None
1.0	Amplification	Resonance

A classic point of departure in considering the principles of vibration control is the concept of a birdcage hanging from a coiled-wire spring. If such a load is pulled downward and then released, it will vibrate at its natural frequency. Its static deflection is the distance the spring elongated when the cage was hung. A forced frequency would be introduced if the top of the spring were hand-held and shaken up and down at a constant rate. The faster this rate, the less tendency there is for the cage to respond, but when the natural and forced-frequencies coincide, response reaches a maximum. In other words, if a frequency match is created, a condition of resonance occurs and the result is amplification of vibration and its attendant troubles. Effective vi- ion isolation depends on the creation of a mismatch quency.

Natural frequency bear ear relation to static shown in Fig. 1. Insula is another concept someti and arrived at by dividi frequency by natural f The ratio is an indicatio effectiveness of a mountin as indicated in Table I. gives the relationship be sulation ratio and vibratio tion—including its negat terpart, amplification. C effectiveness of vibration rises with the insulation r an insulation ratio of $\sqrt{2}$, absorption is zero, and sus tem would provide no con

As pointed out by Conn

* Connon, J. A., Vibration Ins Structural Rubber, AIEE Tech. Pa

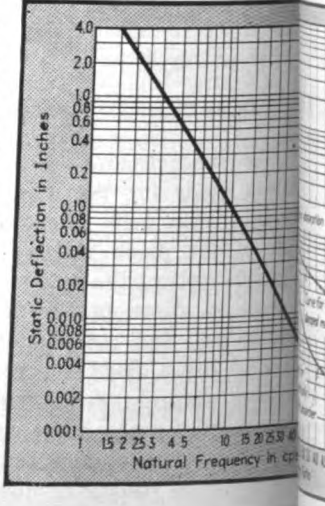

FIG. 1—Resonance can be deter from this linear relation between deflection and natural frequency spring system. A mismatch is des to avoid resonance and amplifi of destructive vibration

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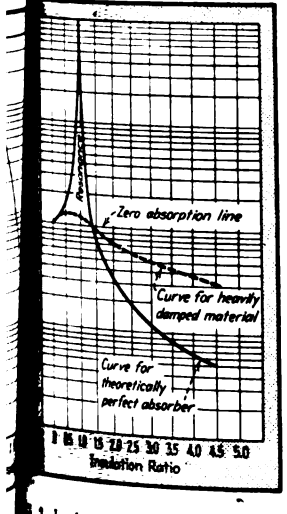
ONTROL for lectronic Products

ew of the many types of specialized units designed to provide isolation and con- destructive vibration and shock. Also included are notes on principles involved in the design of mountings

forces at a given point in occur in several direc- different frequencies and erent amplitudes and may translatory and rotary nts. Vibration in each di- ust be considered with re- the natural frequency of ient suspension in that di- Figure 3 is a typical ship- cord which shows the dif- haracter of the fore-and- vertical, and the athwart- ponents.

Source and Cure

nd large, the complicating cies relate to those of ro- r reciprocating mechanisms re in the equipment or its s. In generalizing on the which can be done to resolve



2—Insulation ratio is an arbitrary obtained by dividing forced fre- by natural frequency. Plotted percent absorption, it shows points at 1, or resonance, and 1.4, where absorption begins

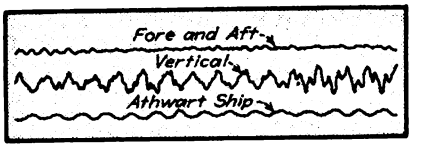


FIG. 3—(above) Components of vibration in a shipboard installation

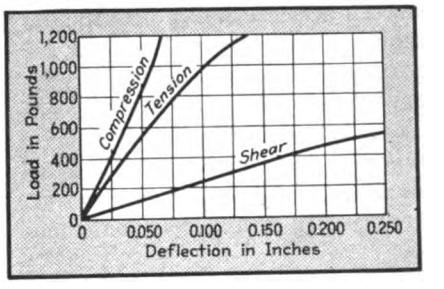


FIG. 5—(right) Shear deflections permit a low natural frequency

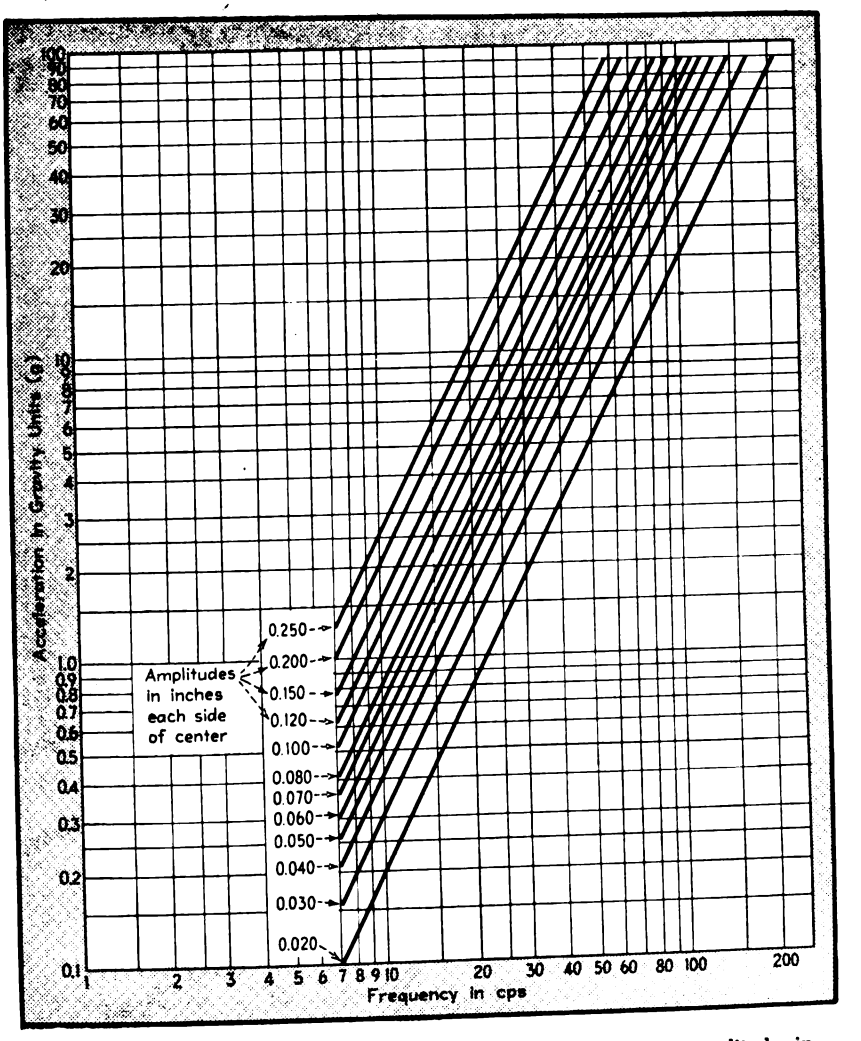


FIG. 4—Family of curves relate acceleration, frequency, and amplitude in accord with the general equation for maximum acceleration of a particle moving in simple harmonic motion

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these factors, it is commonly recommended that mounting units be used which have the greatest deflection consistent with stability; that the mounting have a highest natural frequency sufficiently below the lowest expected forced-frequency to give adequate insulation; and that the softest axis of the mounting be installed parallel to the direction of the greatest induced disturbance.

Harmonic Motion

Figure 4 shows the relationship between acceleration in g units and frequency in cycles per second for a series of amplitudes. These curves were derived by W. A. Dickinson, Sylvania Electric Products, from the general equation for maximum acceleration of a particle moving with simple harmonic motion

$$a_g = \frac{(2\pi f)^2 x}{g} = 0.102 f^2 x$$

where a_g is acceleration in gravitational units, f is frequency in cps, x is amplitude in inches, and g is acceleration due to gravity in inches per second. Vibration problems are generally more complex than simple harmonic motion.

The foregoing notes on theoretical considerations apply to spring systems generally where the elastic member deflects according to Hooke's Law, which states that within the elastic limit of any body, there is a constant ratio between stress and strain produced.

Among fabricated components, rubber mountings are available in a wide range of styles. They can be further classified by the rubber is utilized in c sion, tension, shear, tors flexure. A large number of ings are of the shear type, the same load ordinarily greater deflection in shear does in a compression or system, which are the oth principal modes of usage. demonstrated in Fig. 5.

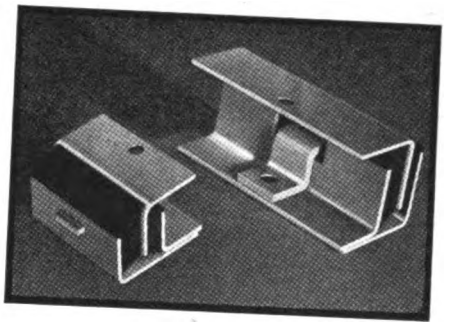

FIG. 7—Three-angle-type mounting includes a locking bar projecting through all parts to hold them together in case of damage to the rubber

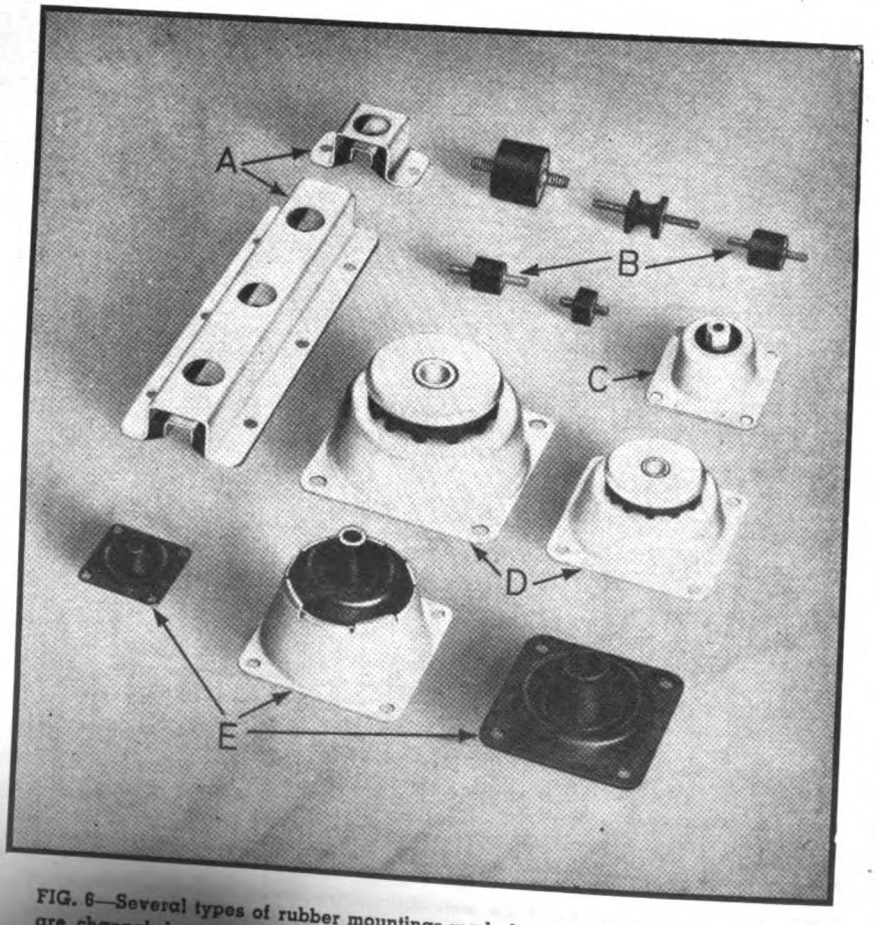

FIG. 6—Several types of rubber mountings made by U. S. Rubber Co. Type (A) are channel-shear mountings; (B) cylindrical compression or shear; (C) safety-type cyli- (D) flexure-compression cups; and (E) flexure

Specialized Components

Among the designs of States Rubber Co. are chann mountings illustrated in Fig These units are used to abs bration in any direction stresses the rubber in shear, are so designed that the load ported on the inner channels nections being made by a which provides a safety f If the rubber bond fails bec fire or accident the support contained within the outer c and the mounted apparatus get away even when sus from above.

In this style, two sizes are able with overall widths of 4¼ in. Each of the two wid available in a number of dif lengths. The smaller is use applications from a minimum of 4 lb, at 50 cps (giving 81 p vibration absorption), to maximum at 25 cps. Range larger size is 24 lb minimum 33 cps (81 percent vibratio sorption) to 420 lb maximu 16 cps. In the smaller size lengths available are 1, 2, 3 a inches, while in the larger size run 1.5, 3, 5, 7 and 9. Vibr control at frequencies higher those noted are better than 81 cent. Loads are given for eac dividual mounting. The would be divided among the n ber of units used to support a g piece of gear.

Figure 7 shows another avail type of mounting which utilizes ber stressed in shear. This on called a three-angle type and classified functionally as a sh sandwich. A safety feature is p vided with this unit in the form a bar which projects through a l eral slot to lock the three ang against disintegration. It is s plied in two sizes—4⅜ in. wide 4⅞ in. long, and 4⅞ in. wide by

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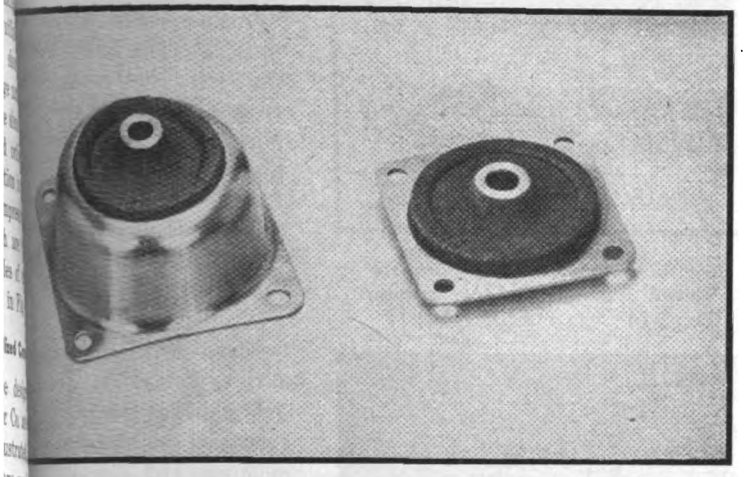

G. 8—Bonded cup-and-plate mountings of these types are offered by Lord Mfg. Co. Rubber is chemically joined to outer metal supports

g. Load ratings range from minimum at 33 cps to 900 lb um at 14 cps.

ndrical mountings are avail- a variety of configurations. wn in Fig. 6(B) they consist ber members bonded on each mounting studs. Circular are listed in diameters of $\frac{7}{16}$, $1\frac{1}{4}$, $1\frac{3}{4}$, $2\frac{1}{4}$ and 3. Square styles ade in the smaller sizes. De- g upon their positional ar- ment, these units can be ed either in shear or in com- on. Their load limits range 0.5 lb minimum at 50 cps to maximum at 21 cps.

ure 6 (C) is a special type ting having a close character- relationship to the cylindrical , but adding the safety feature enclosing cup. In this type ad range is 3 lb at 31 cps ver- and 15 cps horizontally, to at 23 cps vertically and 13 cps ontally.

ountings indicated as Fig. 6(D) classified as flexure-compres- cups. They give about the spring rates horizontally as do vertically. The load deflec- curve on this type is smooth, hout any discontinuity at the t where the bumper comes into which makes them valuable repeated shock loads where the nting frequently strikes against limiting bumper. Having a imum load faculty of 6 lb at 55 the two sizes illustrated cover range to 20 lb at 31 cps.

For equal horizontal and vertical ing rates, another type has been eloped utilizing the elastic mem- flexure. This is shown in Fig. 6(E). Units in this family exhibit large deflections under light loads and make it feasible to control vibration of a relatively low frequency. At a minimum load of 1 lb, 81 percent vibration-control by the smallest size goes down to 31 cps, while the largest extends to 35 lb at 15 cps.

Mountings of a rectangular type are supplied in the following sizes: $1\frac{7}{16}$ by $5\frac{7}{8}$ in., $2\frac{1}{2}$ by $6\frac{3}{4}$ in., and $2\frac{1}{4}$ by 8. Load limits here range from 30 lb minimum in shear at 40 cps to 1,050 lb maximum in compression at 20 cps.

Other products of the company include special circular indicating-instrument mountings, compression cup mountings which are primarily designed to stop the transmission of noise through structures; multi-action units which are useful for absorbing vibration in one direction only and at the same time acting as guides to restrict movements in other directions; heavy duty shear sandwiches capable of carrying loads up to 3,000 lb; compression pads; rubber bumpers in various types and designs; square pads; and structural cellular rubber in slabs which can be used to support an entire section of a larger structure.

Specializing in shear type mountings, Lord Manufacturing Co. offers a line of tubular types which utilize rubber bonded to the adjacent inner and outer diameters of coaxial cylinders. These range from rated loads of 23 lb to 1450 lb and in length from $\frac{7}{8}$ in. to $5\frac{3}{4}$ in. They are divided into six sub-types, with rated deflections of 0.065, 0.068, 0.078, 0.092, 0.108, and 0.123 in.

Another standard line of the same company consists of a series of plate-type mountings as illustrated in Fig. 8 with a choice of square, diamond-shaped, round and cup-shaped metal holding-members. The lenticular rubber disk is bonded to the interior of the circular hole in the mounting member and the load is attached to a bolt through the central bushing. Here, maximum allowable loads range from 1 lb to 120 lb with 1-, $1\frac{1}{2}$- and 2-in. diameter rubber members and $1\frac{1}{4}$- to 3-in. overall dimensions. Normal

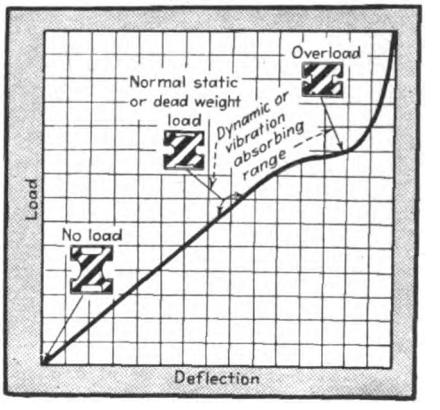

FIG. 9—Mountings with no-load cross-section as shown in lower diagram deform for increasing loads. Metal and rubber parts are held together without bonding. Rubber bar slips into metal channel from the end. The manufacturer is Hamilton Kent Mfg. Co.

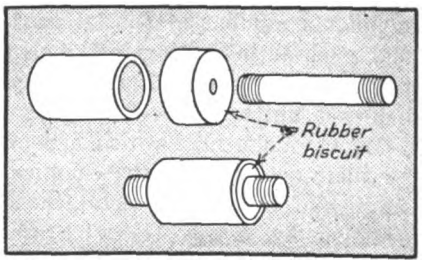

FIG. 10—Friction and pressure hold the three parts of this General Tire and Rubber Co. unit together. Radial, conical, and axial loads are accommodated

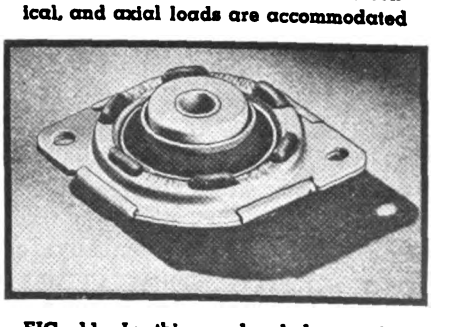

FIG. 11—In this non-bonded mounting by Harris Products Co. the outer support is crimped together with rubber lugs projecting through the metal. The central mounting hole is stabilized by a tube and retaining

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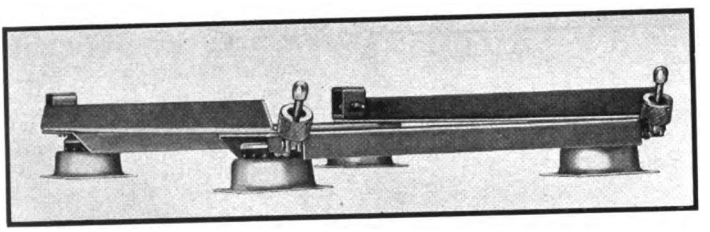

FIG. 12—Here the mounting base is a framework which exactly fits the piece of gear with which it is used. This type is shown suspended on four flexure-compression-cups (Fig. 6-D)

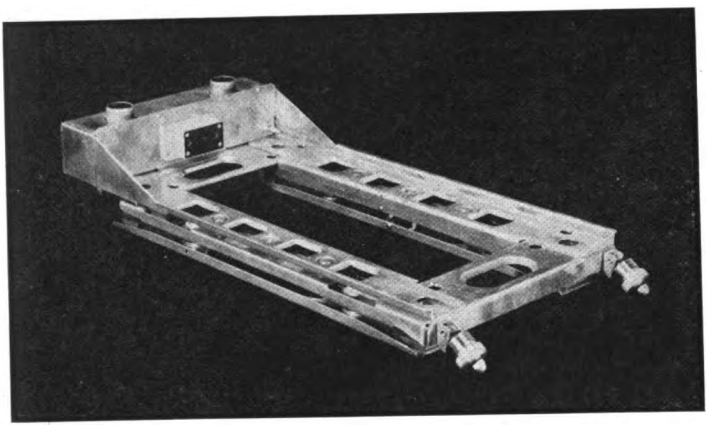

FIG. 13—Mounting base of another type is designed by Robinson Aviation, Inc. as a unit to fit equipment not only physically but from a vibration point of view as well. Also incorporated are plug-in electrical connections in unit at the rear called a doghouse

rating of this series ranges from 1 to 90 lb at $\frac{1}{8}$-in. deflection. (Frequencies can be read from Fig. 1.)

The full listing of the company includes a number of special products, such as indicating-instrument mountings and small specialized disk-type units.

Among mountings which depend for their action upon the chemical bonding of rubber and metal, those designed by B. F. Goodrich Co. show several variations from previously described types. A special style of shear sandwich $4\frac{1}{2}$ in. square is supplied with four mounting studs on each opposite face. It is suggested for a maximum load of 400 lb, at which it exhibits a shear deflection of 0.17 in. and where it is effective on a minimum disturbing frequency of 16 cps.

A channel-type mounting designed by this same company for shear action is similar to those previously described, except that the supporting channel is not surrounded by the base channel. This unit is $4\frac{1}{2}$ in. wide by $1\frac{3}{8}$ in. high and is rated at 50 lb per inch of length with a $\frac{1}{8}$ in. deflection and a minimum disturbing frequency of 16 cps. It is available in these lengths: 1, 2, 3, 6, 12, 24, 36 and 60 in.

Other available units include cylindrical, pedestal, offset shear sandwiches and compression-washer type mountings.

Not all rubber mountings depend on chemical bonding for their action. One type of mounting consists of a rubber x-bar member, as shown in Fig. 9, which slips into upper and lower metal containing elements. The supplier of this unit is the Hamilton Kent Mfg. Co., Kent, Ohio. One of the advantages attributed to this type of design is revealed by the load versus deflection curve shown. The dip in the upper third of the curve shows that deflection increases quite rapidly for small increments of load. This action at the overload point destroys any tendency for resonance and bounce.

Two types of mounts are offered for the handling of all types of vibration: one serves against horizontal, vertical, rotary, or inclined vibration, while the other is for purely vertical action. Units of the first type are cataloged in sizes from 6 by 9 in. to $9\frac{1}{2}$ by 15 in. in horizontal area by $2\frac{7}{8}$ to $2\frac{11}{16}$ in. high for a deadweight load ranging from 225 to 3,800 lb. In the vertical type, sizes range from 6 by 7 in. to $9\frac{1}{2}$ by 13 in. for the same load ranges.

Another method of securing rubber and metal is used by General Tire & Rubber Co. Their mountings gain adhesion by pressure and frictional resistance rather than molding and cementing. In a mounting of this type for radial, conical or axial loads, a separately molded rubber biscuit is contracted into a metal sleeve of smaller diameter as shown in Fig. 10. With a tapered mandrel, the inner diameter is expanded and the inner sleeve inserted.

In another type of non-bonded mounting offered by Harris Products Co., the rubber members are molded in separate parts. As shown in Fig. 11, outer rings are clamped together to secure rubber bosses into peripheral holes which lock the assembly. The inner boss is reinforced by two retainers and a center tube which maintains it in positive position. The units are supplied in square cups, square plates and diamond-shaped plates, and their load ratings, with 1/16-in. deflection, range from $\frac{1}{4}$ to 45 lb. Square bases are available in 1-11/16, 2-3/8, and 3 in., while the diamond-shaped units have lengths of 1.66, 2.32 and 2.97 in. All are supplied alternatively in steel and dural.

Subassembly Types

One of the current trends, particularly in the installation of electronic equipment in aircraft, is toward the use of mounting bases which exactly fit the piece of equipment to be installed and often incorporate sliding plug connections for electrical circuits. Examples of this are shown in Fig. 12 and 13. Fig. 12 is a base made up by combination of a set of four standard unit mountings of a type previously described with a metal subframe which fits under the equipment to be mounted. Fig. 13 shows a somewhat different type of unit

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which is engineered as an complete mounting-base subassembly. The manufacturer is Robinson Aviation Inc. Derived from early and effective aerial camera mounts, this unit operates on a crossed-axis principle, elaborated in Fig. 14. As shown in the diagram, primary cushions *P* absorb part of the initial vibration impulses about the axis *X*. Residual vibration is conducted along structural members to secondary cushions *S* mounted on axis *Y*. These absorb a large portion of the residual vibration, passing along through the supporting unit something ordinarily less than 5 percent of the amplitude of the original driving impulse. A typical vibration absorption curve as shown in Fig. 15 reveals that action is quite effective between 10 and 60 cps, which is the range used in many tests.

In the construction of these units eight special cushion blocks of low density rubber are assembled into the base, at points of minimum motion, where they act with optimum effectiveness. Each block has a top and bottom convex curvature, as revealed in Fig. 16(A), which disappears under load but assures even distribution of stress throughout the block. Figure 16(B) and 16(C) demonstrate compression and shear action of these blocks.

Combination Units

Special characteristics are designed into many of the heavier-duty units by combinations of steel springs, cork and rubber pads and even wood chocks. A multi-purpose type produced by the Korfund Co., Inc., suitable for the control of vibration in all directions, is illustrated in Fig. 17. It consists of a welded structural steel housing incorporating cold-rolled oil-tempered crucible-steel springs. The upper and lower members of the housing are held in a relative position against lateral movement by four resilient chocks.

Equipment to be isolated is fastened to the top plate by means of a bolt passing through the machine base and bearing on a plate which transfers the load to the springs visible inside the unit. Top and bottom plates of the housing are held in vertical relation to each other by bolts isolated with resilient washers.

Six sizes are offered to apply against a range of rated loads from 200 to 12,000 lb. Units weigh 7, 18, 32, 36, 49 and 60 lb. respectively, and have overall dimensions of 2½ by 6⅞; 5 by 6⅞; 5 by 9⅛; 7 by 9⅛; 7 by 11½ and 7 by 11½ in. on bases.

One of the latest types of vibration controls to be reported is one which is described as dissipating vibratory and shock forces in the form of heat. These absorbers consist of series of very thin sheets of metal, generally copper, placed one on top of the other and inclosed in an air-tight welded jacket. Mountings are used in compression, have no natural frequency, do not acquire a set in operation, and are unaffected by such conditions as moisture, oil, dust, and steam. Among sizes available are units as small as ¼ in. in diameter, standard types 4 by 4 by ¼ in., and others as large as 6 by 12 ft. by ½ in.

Construction of these molecular vibration absorbers is based on a principle of discontinuities. Maximum reflectivity is produced by placing in contact two media whose difference in resistance to sound conduction is a maximum.

The manufacture of the unit involves locking to the surface of the metals a liquid film, and to this, a film of air. The liquid and air films are harder than steel and when used in connection with thin metal plates form an assembly possessing maximum discontinuities. The manufacturer, Chamberlain Laboratories, points out that, since such a large amount of work is done on a very small amount of air, its temperature rises above incandescence. Heat is instantaneously dissipated by radiation—F. H.

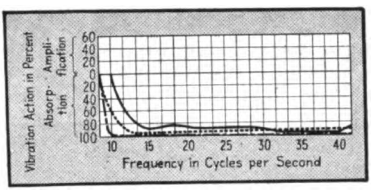

FIG. 15—Vibration absorption curve shows action of the mounting base illustrated in Fig. 13. The absorption range between 10 and 60 cps is widely used in tests. The solid line represents the vertical component; dotted, longitudinal; and dashed, lateral

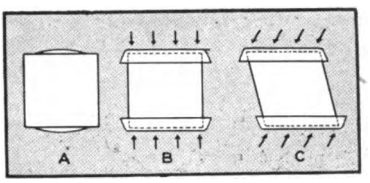

FIG. 16—Eight specially compounded rubber blocks of the conformation shown at (A) are represented by *P* and *S* in Fig. 14. The convex top and bottom flatten under load as shown in (B) and the blocks have uniformly distributed stresses

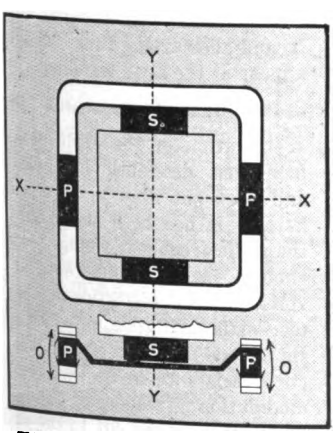

FIG. 14—Crossed-axis suspension is the principle used by the unit illustrated in Fig. 13. Primary cushions are indicated by P, secondary by S, respectively on the X and Y axes. Arcs O represent the limits of oscillation

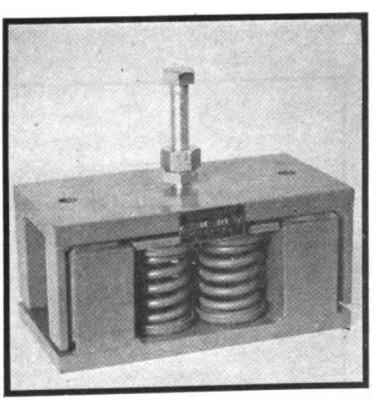

FIG. 17—Heavy-duty isolators are available in spring types like this from The Korfund Co., Inc. Bolt on top transfers the load of the mounted gear to the spring-borne plate immediately beneath

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Stabilized NEGATIVE

By E. L. GINZTON

Research Engineer
Sperry Gyroscope Company, Inc.
Garden City, New York

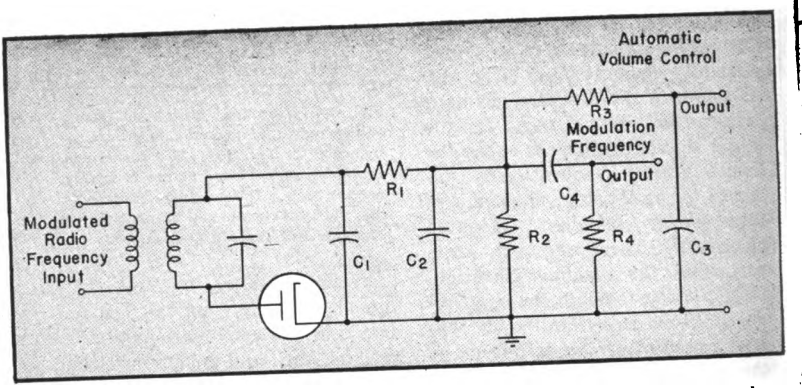

FIG. 21—Typical diode-detector circuit which can be improved by addition of negative impedance

Negative impedances are used to correct non-linearity of diode detectors by making the load ideal, to improve regulation of variable-voltage power supplies by cancelling their internal impedances, and to increase selectivity of resonant circuits by counteracting losses

BY WAY OF ILLUSTRATING types of applications to which stabilized negative impedances can be put, several specific uses will be described. The aim is more to show how one goes about utilizing negative impedances than to list their uses. Only engineering adaptability can find all the uses and the simplest methods; this merely sugests where to start.

Improvement of Diode Detector

A practical diode-detector circuit is shown in Fig. 21. The diode is used as a rectifier, being substantially a short circuit on one-half cycle, and an open circuit on the other half. The load circuit consists of a network which has several functions. The load resistance is shunted by capacitor C_1 which is large enough to act as an effective short circuit for the radio-frequency voltages and yet in an ideal case must not shunt the load resistance for the highest modulation frequency that the detector is to handle. R_1 and C_2 form a filter which isolates the radio-frequency voltage that may exist across C_1 and allows only the modulation-frequency voltage to appear across the output R_2 of the circuit. Capacitor C_4 in conjunction with the resistance R_1 separates the modulation-frequency voltage from the direct-current voltage which is present across the load circuit, a filter arrangement which is often necessary to keep d-c voltage from the following amplifier grid and to utilize the d-c voltage for automatic volume control in a radio receiver. R_3 and C_3 form a filter which isolates the modulation-frequency voltage that exists across R_2 and allows only direct voltage to appear at the a-v-c terminal.

Diode Characteristics

Operation of the diode detector has been described in literature and does not need to be repeated here.[14] It has been shown that if the radio-frequency voltage is large enough, in the neighborhood of 20 volts, then the distortion due to detection is negligible, provided that the diode-detector circuit has a pure resistance in its load for the modulation frequencies and an effective short circuit to the radio frequencies. A diode detector under these ideal conditions may be considered as distortionless.

An actual detector circuit shown in Fig. 21 is far from being ideal

PART I

Basic ideal circuit and fundamental equations for producing the negative of a positive impedance. Eq. (1)-(29), Fig. 1-9, Ref. 1-10

PART II

Effect on negative impedance of variations with frequency of amplifier parameters. Eq. (30)-(56), Fig. 10-20, Ref. 11-13

PART III

Illustrative applications of negative impedances show how improved circuits can be obtained. Eq. (57)-(67), Fig. 21-27, Ref. 14-16

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IMPEDANCES --- Part III

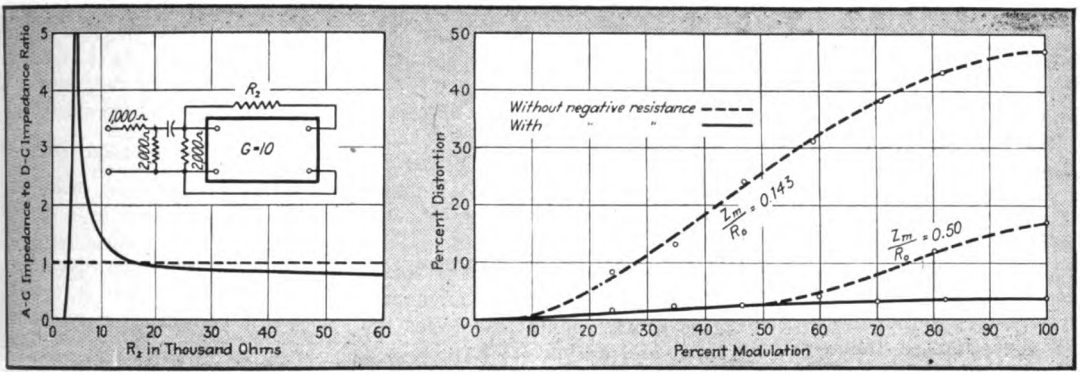

FIG. 22—Addition of negative resistance to diode detector improves the a-c to d-c impedance ratio

FIG. 23—Negative resistance added to a diode detector decreases distortion near 100 percent modulation

and will produce serious distortion. The manner in which the actual circuit shown here deviates from the ideal detector can be seen from a study of Fig. 21. The load circuit of the detector, due to various capacitors in the circuit, presents a lower impedance to the modulation frequency than it does to the direct current.

Let Z_m be the impedance offered by the diode load circuit to the modulation frequencies, and R_o the resistance offered by the same circuit to the direct current. While it is not readily obvious, Terman has shown that the maximum percentage of modulation m that the diode detector with a given load can rectify without distortion is

$$m = Z_m/R_o \qquad (57)$$

If the actual percentage of modulation of the applied radio frequency signal exceeds this value, the rectified output will be distorted. The nature of the distortion depends upon the nature of the ratio Z_m/R_o. If this is a reel constant, then the distortion will be in the nature of clipping of the negative peaks of the modulation frequency wave. If the load is such that the above ratio (commonly called the a-c to d-c ratio) has a phase angle, then the distortion will be clipping of the negative peaks at an angle with respect to the axis of the rectified wave. The wave-shape of the distortion is not important in this discussion.

The important fact is that the diode detector deviates from the ideal distortionless detector in two ways: (1) Modulation-frequency impedance does not equal the d-c resistance of the diode load. This produces clipping of the negative peaks if the actual degree of modulation exceeds Z_m/R_o. (2) Modulation-frequency impedance has a phase angle due to the fact that the shunting capacitor C acts as a partial short circuit at the higher modulation frequencies. This causes diagonal clipping of the negative peaks.

Improvement by Using Negative Resistance

The two effects which cause deviation of an actual diode-detector circuit from the ideal detector can be eliminated by the application of stabilized negative impedances.

The first of the two effects can be eliminated entirely by means of a negative resistance of the shunt type placed across the diode load at the output terminals.[25] The negative resistance may be so adjusted that its value is just equal to the shunting resistance which causes the difference between Z_m and R_o. This will make the ratio given by Eq. (57) just equal to unity which, in turn, means that 100 percent modulated signals can be rectified without distortion.

The second of these deviations from the ideal may be eliminated by using a negative capacitance supplied by an amplifier which has a uniform response up to the highest modulation frequency that it is intended to use, and yet which cuts off considerably below the carrier frequency. By means of this arrangement it is possible to make the net capacitance across the load, as far as modulation frequencies are concerned, just zero and there will be no diagonal clipping even for 100 percent modulated signals. And yet, because the amplifier cuts off at some intermediate frequency, the negative capacitance will be absent above cut-off and the net capacitance offered to radio frequencies across the load will be equal to something greater than C_1.

Measurements of Improved Detector

It is seen that by means of two kinds of negative impedances an ordinary diode detector can be made to approach the ideal one very closely. The principle is illustrated experimentally by means of a diode detector which was purposely made to have a very poor a-c to d-c ratio. Figure 22 shows the a-c to d-c ratio of the diode load (measured by an ohmmeter to determine R_o, and by the voltage-current method to measure Z_m) as a function of the negative resistance placed across the diode load. It is seen from this graph that the proper amount of negative resistance across the diode load causes the a-c to d-c ratio to become unity.

Figure 23 shows the distortion produced by a diode detector as a

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function of degree of modulation for a detector which again had a purposely poor Z_m/R_o ratio in one case, and a typical one in another. In both cases the distortion of 100 percent modulated signals is very high. By means of a proper amount of negative resistance placed across the diode load, the Z_m/R_o ratio was made unity in each case and the distortion measurements repeated. The results are indicated by the solid curve.

It should be mentioned that the distortion was measured by a wave-analyzer at the output of the amplifier that supplied the negative resistance. The measured distortion in each of the three curves is the sum of all distortions due to the modulation-frequency oscillator, the modulator, the radio-frequency amplifier, the diode, and the audio-frequency amplifier used to supply the negative resistance.

The amplifier that supplies the negative resistance does not need to be a separate amplifier. The conventional radio receiver usually has two stages of audio frequency amplification after the diode detector. An addition of one resistor of proper value may be sufficient to make the Z_m/R_o ratio equal to unity and eliminate a large part of the distortion that results when high percentages of modulation are present.

Typical circuit of a diode detector and two-stage amplifier that might be found in a commercial radio receiver is shown in Fig. 24. The amplifier may be stabilized by negative feedback for better performance, but that is not essential, although highly recommended. A proper value of R_s will develop a negative resistance of the shunt type and in combination with R_4 will form an open circuit so that the Z_m/R_o ratio will be unity.

Capacitance Multiplication

It was shown that if an impedance Z_s was connected between the input and the output terminals of an amplifier, the input impedance of the amplifier was given by Eq. (13). If Z_s is a pure capacitance, the input impedance of the amplifier will be a capacitive reactance whose magnitude is given by

$$Z_n = \frac{1}{j\omega C_2(1 - G)} \qquad (58)$$

If the amplifier is so arranged that the output of the amplifier will be of opposite relative phase to its input, then the gain of the amplifier will be a negative number, and so this equation becomes

$$Z_n = \frac{1}{j\omega C_2(1 + G')} \qquad (59)$$

where G' indicates that it is a negative of the previously used symbol G. The input impedance is thus a capacitive reactance, with the equivalent value of

$$C_{eq} = C_2(1 + G') \qquad (60)$$

which means that the capacitance C_2 is multiplied by the factor $(1 + G')$. It must be remembered, however, that in series with this capacitance there is a resistive component due to the inevitable output resistance of the amplifier.

Use of Negative Impedance Techniques

A pure capacitance multiplication can be obtained by a scheme similar to the method used in obtaining a pure negative reactance, If a capacitance is found to possess a certain series resistance, this can be eliminated by placing a negative resistance of the series type in series with the amplifier in the manner previously described. By making the negative and positive resistances just equal, a pure capacitance can be obtained. Another possible way of obtaining a pure negative capacitance is by utilizing a zero-output impedance amplifier.[16]

In some cases it is desirable to have a two-terminal impedance which will be small for all audio-frequencies and yet act as an open circuit for direct currents. Such an impedance may be obtained in the manner described above. In the frequency region where the amplifier supplying the multiplied capacitance has a uniform frequency response, the resistive component will be constant and its

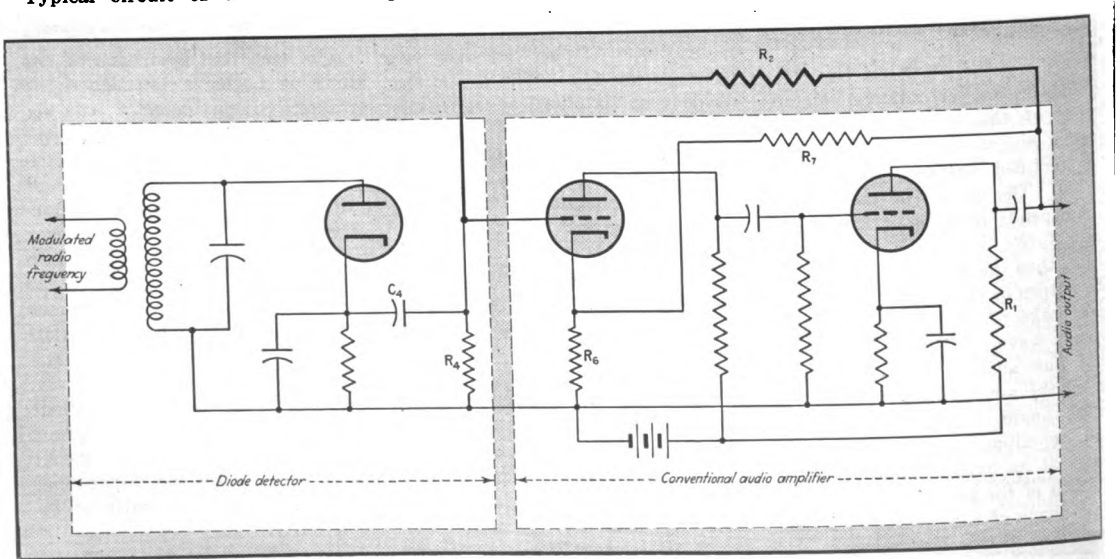

FIG. 24—Application of negative resistance to improve diode detector in conventional radio receiver requires addition of only one resistor

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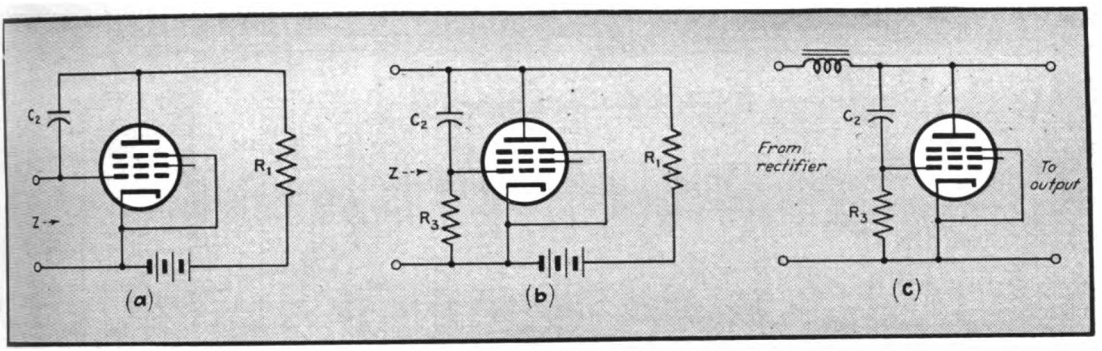

FIG. 25—Using principles on which negative impedance has been discussed, a single tube can be used to multiply capacitance as at (a) for a-c circuits, or as at (b) for combined a-c and d-c circuits for such applications as filters (c)

magnitude is given by Eq. (11) with G replaced by G'.

$$R = R_1/(1 + G') \qquad (61)$$

If C_2 is so large that the resultant circuit is merely a resistance to all frequencies for which the amplification G' is constant, the amplifier will act as a low a-c resistance, but will not pass direct current. Such an element is useful in power supply filters where it may be desired to use it as a voltage regulator or where it is desired to produce better filtering than can be done without resorting to very large capacitors. This use is illustrated in Fig. 25.

Single-Tube Capacitance Multiplier

In Fig. 25(a) is shown a single-stage amplifier which has the proper phase relations to act as a capacitance multiplier. The amplification is best obtained by means of a pentode which has a high mutual conductance. The voltage gain of this amplifier is $G' = G_m R_1$, so that the input impedance of the amplifier is

$$Z = \frac{1}{j\omega C_2(1 + G')} + \frac{R_1}{1 + G'} = \frac{1}{j\omega C_2(1 + G_m R_1)} + \frac{R_1}{1 + G_m R_1} \qquad (62)$$

where G_m is the mutual conductance of the tube. If the reactance of capacitor C_2 is large enough, the input impedance of the amplifier will simply be $Z = 1/G_m$ providing the voltage amplification is much larger than unity.

Tubes such as 6AC7 or 6SG7 have a mutual conductance in the neighborhood of 10,000 micromhos so that it is possible to obtain an input resistance of 100 ohms for all frequencies for which the assumption made above regarding the magnitude of C_2 is true. This means that a tube of this sort is equivalent to a capacitance of 26.5μf at 60 cycles, or to a capacitance of nearly 1600 μf at a frequency of 1 cps. The capacitance of C_2 merely needs to be large in comparison to R_1 at these frequencies, which is simple because R_1 can be made as large as one desires.

A slightly different arrangement shown in Fig. 25(b) differs from the amplifier just discussed in two respects. If in the amplifier shown in Fig. 25(a) a very large resistance R_3 is placed across the input terminals, it will not affect the validity of the equations derived above. Also, if C_2 is very large, then it does not make any difference on what side of C_2 the input impedance is measured, and therefore, the equations derived for Fig. 25(a) are true for Fig. 25(b). Figure 25(b) has the advantage that a direct-current voltage may be impressed upon the device without disrupting the normal operation of the tube. Thus, this arrangement can be utilized in a power-supply filter in the same manner as an ordinary capacitor.

Further modification of the circuit is shown in Fig. 25(c) where the device is shown in a conventional power-supply filter circuit. The power supply itself supplies the necessary current for the tube and the parallel combination of load and power supply resistances constitute the equivalent of resistance R_1 of the former two circuits. In Fig. 25(b) and 25(c) the capacitor C_2 needs to be large enough only in comparison with R_3 which makes it particularly simple to obtain a device which will filter at the very low frequencies.

Negative Resistance Increases Tuned-Circuit Q

Consider a parallel combination of an inductor L and a capacitor C. If L is a pure inductance, and C is a pure capacitance, then the impedance at resonance becomes infinite. If the circuit L contains resistance R, then the impedance at resonance will be determined by the figure of merit of the circuit, commonly known as Q, which is defined as $\omega L/R_0$, and the impedance at resonance will be $R_0 = \omega LQ$.

Often it is desirable to have a higher shunt impedance than can be obtained by the best coil that is available. This difficulty can be overcome by introducing either a series negative resistance in series with the coil, or a shunt negative resistance in parallel with the coil. By properly adjusting the magnitude of the negative resistance, any value of Q can be obtained from the original one up to infinity. If, for example, we let R_0' be the shunt impedance of the tuned circuit at resonance, and assume that a shunt type negative resistance of magnitude R_n is placed across the tuned circuit, then

$$R_0' = \frac{R_0 R_n}{R_0 + R_n} \qquad (63)$$

$$\frac{R_0'}{R_0} = \frac{R_n}{R_0 + R_n} \qquad (64)$$

and the effective Q of the combination will be

$$Q_{eff} = Q\frac{R_n}{R_0 + R_n} \qquad (65)$$

The stability of this increased Q must depend upon the actual increase in Q. This may be found as follows:

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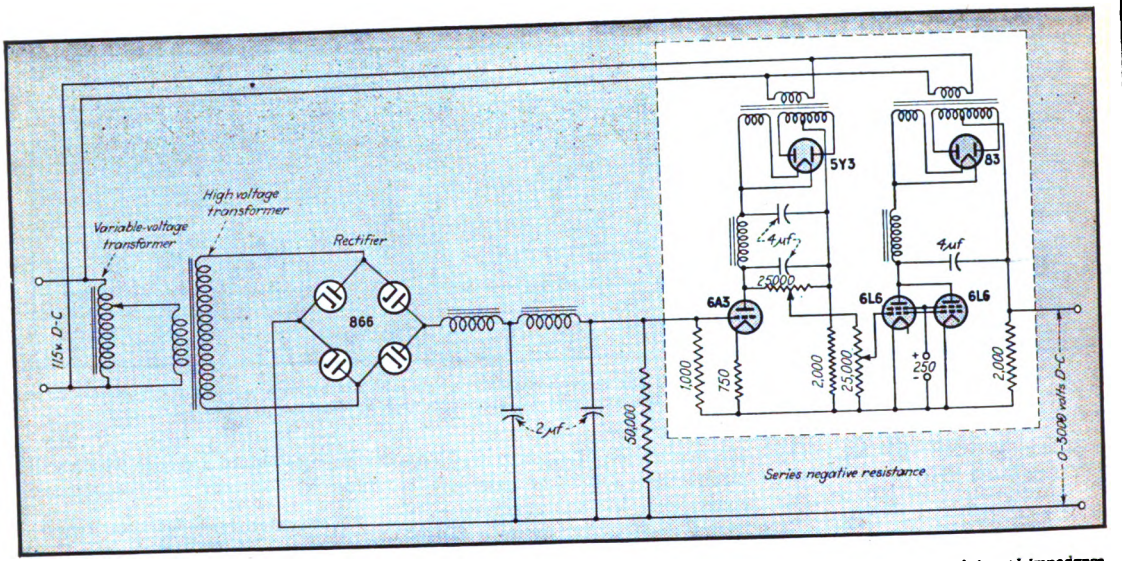

FIG. 26—Continuously-variable regulated-output power supplies can be built using negative resistance to give zero internal impedance

$$\frac{\partial Q_{eff}}{\partial R_n} = Q\frac{R_0}{(R_0 + R_n)^2} \qquad (66)$$

$$\frac{\partial Q_{eff}}{Q_{eff}} = \frac{\partial R_n}{R_n}\left[\frac{R_0}{R_0 + R_n}\right] \qquad (67)$$

From Eq. (67) it is plain that as R_n approaches R_0 the stability becomes very poor and at the point where Q_{eff} becomes infinite, the stability becomes infinite (See Eq. (18) and (27) and oscillations must take place. But due to the fact that the negative resistance may be stabilized very well by means of negative feedback, a considerable increase in Q is possible with reasonable stability. For instance, some stability figures were previously given for a typical amplifier. It was found that a 20 percent change in supply voltage produced a change in A of 8 percent. With $\beta = -0.1$, and $A = 10{,}000$, the stability coefficient was found to be nearly 10^{-4}, or $\partial R_n/R_n$ from Eq. (17) is $(1/1000)\,(8/100) = 8 \times 10^{-5}$ If it is further assumed that L is wound with copper wire and that a 10°C variation in temperature may take place, the original Q of the coil may vary by 4 percent. If Q_{eff} is regenerated to the point where the 20 percent variation in supply voltage will produce a 4 percent change in the Q, then $R_0/(R_0 + R_n) = 500$.

This means that by this method it is possible to increase the selective properties of a tuned circuit by a factor of 500 and still have a resultant stability which is not worse than the stability of the original coil due to temperature variations. Actually, such an increase in Q_{eff} cannot be used without providing temperature compensation.

Tuned circuits regenerated in this way have many applications. They can be used in filters, wave analyzers, or in any other application where it is desirable to have a higher degree of selectivity than is made possible by ordinary coils.

Improvement of Power-Supply Regulation

In certain applications it is sometimes necessary to have a power supply which has negligible voltage variation with changing current, or in other words, a power supply with zero internal resistance. This can be accomplished by various types of well known voltage regulators. For use with Klystrons for instance, another feature is sometimes essential: a method of controlling the voltage of the power supply continuously from zero to maximum with voltage regulation over the entire range. This requirement eliminates most of well known regulators and makes others impractical.

If a negative resistance is placed in series with a power supply and its magnitude adjusted so that it just cancels the internal resistance of the power supply, then the power supply in conjunction with the negative resistance will have a zero internal impedance and a varying load will not affect output voltage.

Figure 26 shows a schematic diagram of a power supply and a series negative resistance. Such an arrangement will make the output voltage of the power supply independent of current taken from the power supply over a wide range of voltages, because the internal impedance of power supply approximates quite well a constant. Figure 27 shows the improvement of voltage regulation of the power supply shown in Fig. 26.

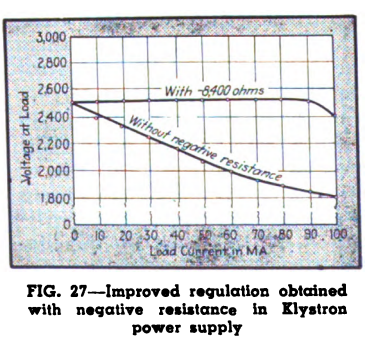

FIG. 27—Improved regulation obtained with negative resistance in Klystron power supply

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(16) Sturm, T., Verfahren zur Klirrverminderung (linearisierung), *Funktechnische Monatshefte*, Mar. 1937, p. 77-82; and Mayer, H. F., Control of the Effective Internal Impedance of Amplifiers by Means of Feedback, *Proc. I. R. E.*, 27, No. 3, p. 213-217, Mar. 1939 (Other authors have also described methods of making the output impedance of the amplifier equal to zero.).

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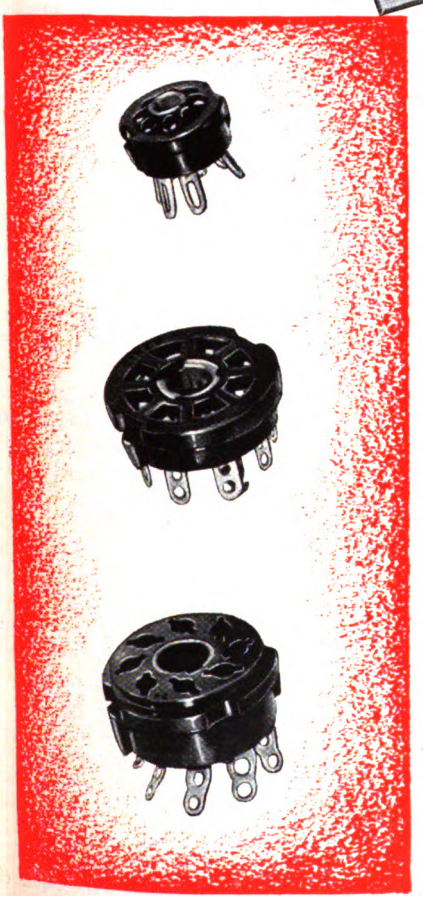

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DETERMINING Q OF CAPACITORS

Chart minimizes calculations needed in converting Q meter readings into the Q factor values of unknown capacitors. Use of fixed capacitor in series with unknown permits extending the procedure to any size capacitor

By E. L. PEPPERBERG

Engineering Department
Zenith Radio Corporation
Chicago, Illinois

WITH the aid of the accompanying chart and a simple calculating procedure, the Q of any capacitor may be easily determined from measurements made with an ordinary laboratory-type Q meter.

The measuring procedure involves setting the Q meter to the frequency at which the capacitor Q is desired, adjusting the meter tuning capacitance C_1 to resonance when nothing is connected to the external-capacitance terminals of the meter, and reading the value of Q_1 applying to the coil used in the measurements. The unknown capacitor is now connected to the Q meter, a new at-resonance setting C_2 is obtained, and the new Q value is read on the meter. The difference between the two settings of the tuning capacitance is then the capacitance value of the unknown capacitor ($C_x = C_1 - C_2$). The first Q reading and the difference between the two Q readings are then applied to the chart to secure the Q of the unknown capacitor.

The chart is based on the equation

$$Q_x = \frac{C_x}{C_1}\,\frac{Q_1 Q_2}{Q_1 - Q_2} \qquad (1)$$

where C_x = capacitance of unknown unit
Q_x = Q factor of unknown unit
C_1 = initial capacitance of Q meter circuit
Q_1 = Q of coil used in measurements
Q_2 = Q of unknown capacitor and Q meter circuit combined

Three practical assumptions have been made in the derivation of this equation: (1) the unknown capacitor has a Q value greater than 10; (2) the tuning capacitor in the Q meter circuit is considered as having an infinite Q; (3) no inductance is present in the capacitors used. With these assumptions, the equation is more nearly correct at the lower radio frequencies.

If Q_2 in Eq. (1) is replaced by $Q_1 - \Delta Q$, the equation becomes

$$Q_x = \frac{C_x}{C_1}\,Q_1\,\frac{Q_1 - \Delta Q}{\Delta Q}$$

$$Q_x = \frac{C_x}{C_1}\,Q_1\left(\frac{Q_1}{\Delta Q} - 1\right) \qquad (2)$$

The chart is based on a value of 0.5 for the ratio C_x/C_1. For other ratios, the Q value obtained from the chart should be multiplied by 2 (to eliminate 0.5), then multiplied by the actual ratio C_x/C_1.

Example 1

Values of $C_1 = 100$ $\mu\mu$f and $Q_1 = 250$ are obtained for the Q meter alone, and values of $C_2 = 50$ $\mu\mu$f and $Q_2 = 240$ are obtained with an unknown capacitor C_x connected to the Q meter. From this measured data, $C_x = 100 - 50 = 50$ $\mu\mu$f, $C_x/C_1 = 0.5$, and $\Delta Q = 250 - 240 = 10$. Tracing horizontally on the chart from $\Delta Q = 10$ to the $Q_1 = 250$ curve, then down to the horizontal reference axis gives 3,000 for Q_x. The unknown capacitor is thus 50 $\mu\mu$f and has a Q of 3,000.

Example 2

Measurements with the unknown capacitor of Example 1 at some other frequency, near the first frequency, give $C_1 = 200$ $\mu\mu$f, $Q_1 = 250$, $C_2 = 150$ $\mu\mu$f, and $Q_2 = 245$. Now $C_x = 200 - 150 = 50$ $\mu\mu$f as before, $C_x/C_1 = 0.25$, and $\Delta Q = 250 - 245 = 5$. For $\Delta Q = 5$ and $Q_1 = 250$ the chart gives a Q value of 6,000 for $C_x/C_1 = 0.5$, and applying the correction factor (because we have a different ratio now) gives $Q_x = 2 \times 0.25 \times 6{,}000 = 3{,}000$. The new frequency thus gives the same value of Q as before.

Large Capacitors

For capacitors too large to be measured on the Q meter in the above manner, three sets of measurements and additional calculations must be made, using results obtained from the chart. A small fixed capacitor C_A is required, of any value that can be measured directly on the Q meter and, with C_A in series with the large unknown capacitor, gives a combined capacitance which can also be measured.

In this procedure, the values of

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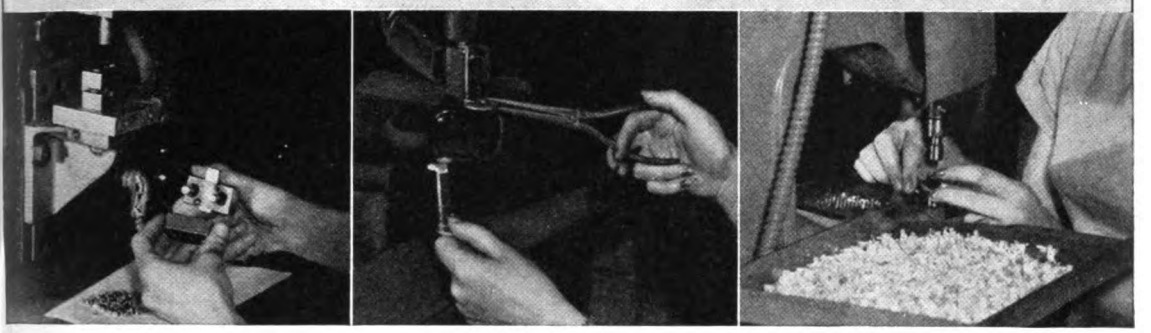

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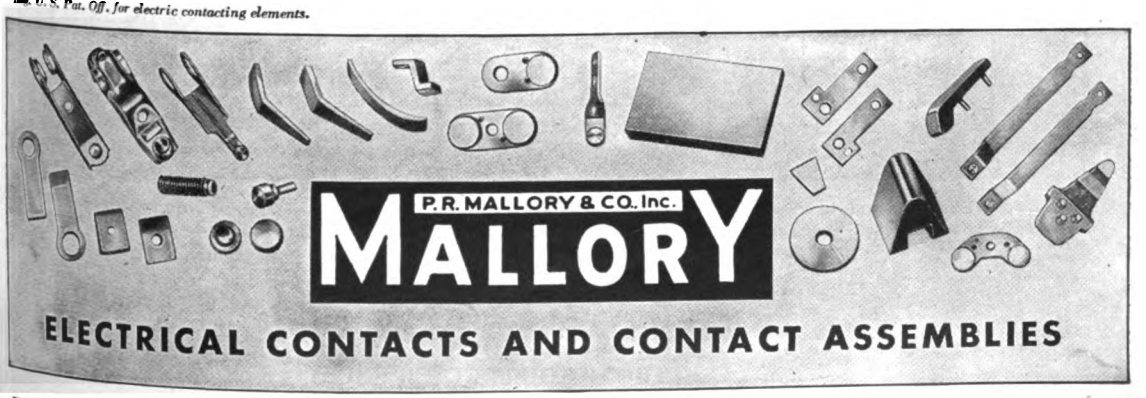

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C_1 and Q_1 are first obtained for the Q meter alone, as before. The values of C_2 and Q_2 are obtained next, with fixed capacitor C_A connected to the Q meter. Finally, the unknown capacitor C_X is placed in series with C_A, and the values of C_3 and Q_3 are obtained. From this data, the capacitance values of C_A and C_X are calculated as follows

$$C_A = C_1 - C_2 \tag{3}$$

$$C_X = \frac{C_A (C_1 - C_3)}{C_A - (C_1 - C_3)} \tag{4}$$

The Q of the fixed capacitor (Q_{X1}) is found with the aid of the chart, just as for the original procedure, and the Q of the series combination of C_A and C_X (designated Q_{X2}) is similarly obtained. The value of Q_X for the large capacitor can then be calculated from the equation

$$Q_X = \frac{Q_{X1} Q_{X2} C_A}{Q_{X1} (C_A + C_X) - Q_{X2} C_X} \tag{5}$$

This equation is based on the same assumptions as for small capacitors. In all calculations the factor 10^{-12} is omitted from capacitance values because the factor cancels out and does not affect final results.

Example 3

Q meter measurements on a fixed capacitor and a large unknown capacitor whose size and Q are desired give the following readings

$C_1 = 400\ \mu\mu f$ $\quad Q_1 = 250$
$C_2 = 100\ \mu\mu f$ $\quad Q_2 = 240$
$C_3 = 169\ \mu\mu f$ $\quad Q_3 = 180$

From Eq. (3), $C_A = 400 - 100 = 300\ \mu\mu f$. From Eq. (4),

$$C_X = \frac{300\ (400 - 169)}{300 - (400 - 169)} = 1{,}000\ \mu\mu f$$

To obtain Q_{X1}, $\Delta Q = 250 - 240 = 10$, $C_{X1} = 400 - 100 = 300$, and $C_{X1}/C_1 = 300/400 = 0.75$. For $\Delta Q = 10$ and $Q_1 = 250$ on the chart, a Q value of 3,000 is obtained. Applying the correction factor, $Q_{X1} = 2 \times 0.75 \times 3{,}000 = 4{,}500$.

To obtain Q_{X2}, $\Delta Q = 250 - 180 = 70$, $C_{X2} = 400 - 169 = 231$, and $C_{X2}/C_1 = 231/400 = 0.578$. For $\Delta Q = 70$ and $Q_1 = 250$, the chart gives a Q value of 320. Applying the correction factor, $Q_{X2} = 2 \times 0.578 \times 320 = 370$.

The Q of the large capacitor then is

$$Q_X = \frac{4{,}500 \times 370 \times 231}{4{,}500\ (300 + 1{,}000) - 370 \times 300} = 912$$

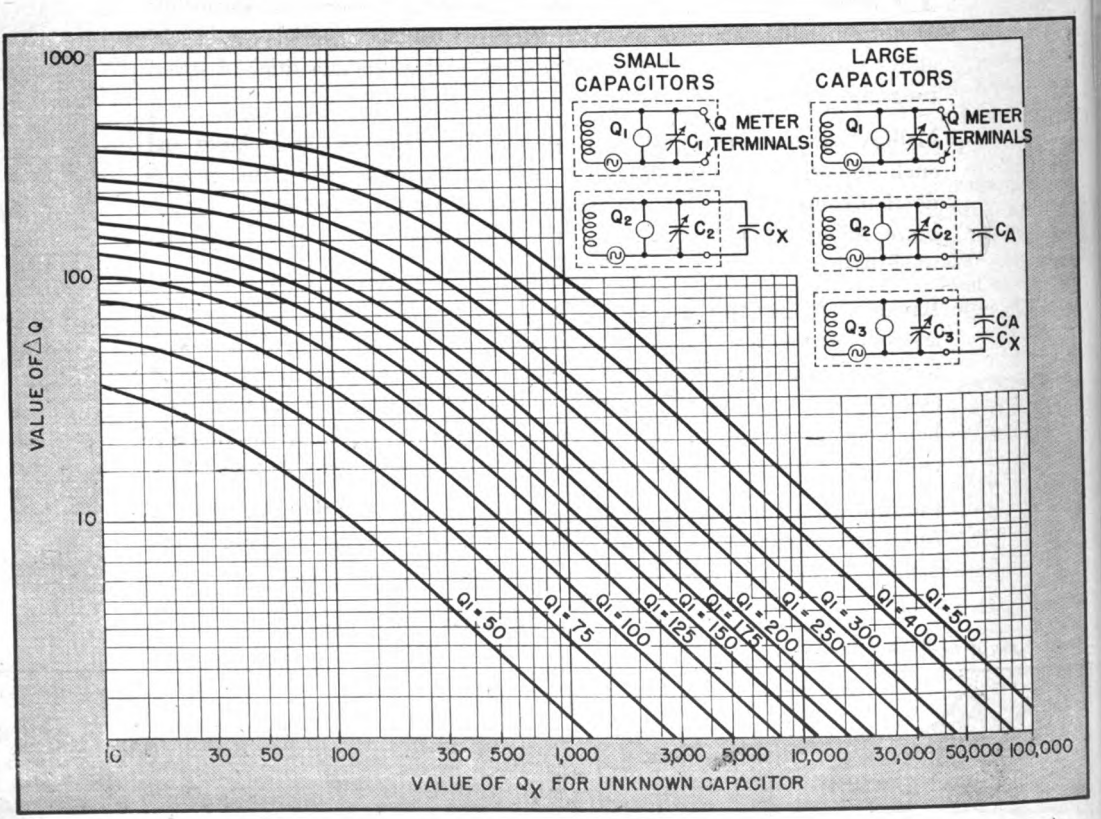

Chart for determining Q value of a capacitor from Q meter measurements. Large capacitors require one extra set of measurements, as indicated by circuits at upper right. Chart applies specifically to measurements in which ratio of unknown capacitance to capacitance C_1 inside the Q meter is 0.5; for other ratios, multiply chart value of Q_X by $2C_X/C_1$

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YOUR CHECK LIST OF NEW IRC PRODUCTS

To a line of resistors already broader than that of any other manufacturer in the entire resistor industry, IRC has, in the last few months, announced several new and important contributions. Among the newer developments having wide-spread application in the electronics field are the components here briefly reviewed. All of these products are available in reasonable quantities except the Type BTR Resistor, which is still wholly allocated to a special war project. However, samples of this unit are available and will be gladly sent for test or experimental purposes. Your inquiries will receive prompt and welcome attention.

TYPE PRT POWER RHEOSTAT

Rugged yet light in weight and of neat appearance the PRT conforms fully with AN3155 specs. Has heavy screw type terminals at rear of enclosed all-metal housing. Available in 25 and 50 watt models.

TYPE BTA 1 WATT METALLIZED INSULATED RESISTOR

Pencil-thin, less than ¾" in length and conservatively rated at one watt the BTA is a quality resistor throughout and meets RC30 specs. Low in operating temperature it has proportionately high wattage dissipation.

TYPE BTR ⅓ WATT METALLIZED INSULATED RESISTOR

Scarcely bigger than a bump on a wire (L. $\frac{13}{32}$"-Dia. $\frac{3}{32}$") the BTR ⅓-watt resistor has all the quality characteristics and features that have long made IRC's BT line "Preferred for Performance." Suitable for Army-Navy RC 10 applications. *Available postwar.*

TYPE FRW FLAT WIRE WOUND RESISTOR

Efficient as a tubular wire wound, the type FRW has many features that recommend it for limited space use. In 5 standard sizes to comply with JAN-R-26, specs for RW 20, RW 21, RW 22, RW 24 requirements.

TYPE GRW GRADE 1-CLASS 1 RESISTOR

Thoroughly dependable and of sound construction these completely sealed units meet or surpass every requirement of JAN-R-26 specs. Made in 7 standard sizes with power ratings of 15 to 140 watts and resistance ranges of 0.1 to 63,000 ohms.

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No bigger round than a nickel and wafer-thin, this control will find many useful applications in the smaller electronic devices. All-inclusive design eliminates the usual knob, shaft and bushing without impairing functional operation.

For more complete, technical information on any of the above IRC products write to Dept. 1-I.

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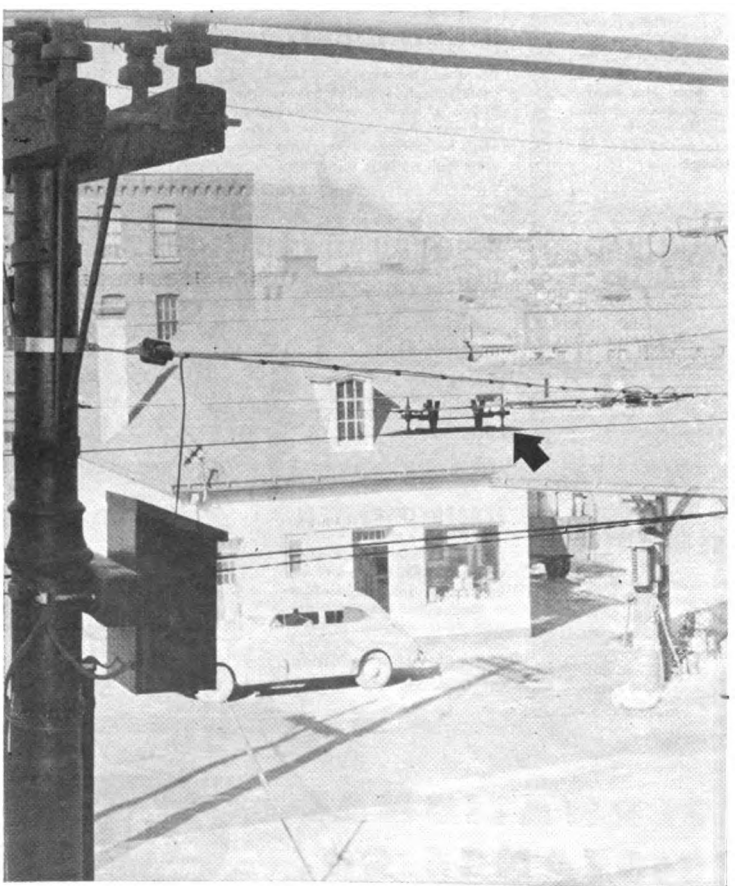
Controlling Activation Schedules At Exhaust 180
Balls for Bearings Sorted by Electronic Gage 192
Electronic Swallow Counter 192
Photo Timer for Time-Motion Study 196

Automatic Control of Vehicular Traffic

USE OF ELECTRONIC tubes in the automatic control of traffic has proved eminently practical as illustrated by applications in large and small cities and along highways. Such a system, developed by the engineers of the Northern Electric Company of Montreal, has been successfully used in Quebec for several years.

Basically there are two elements to the system, detectors and dispatchers. Dispatching of traffic is done by a control mechanism whose function is to receive the impulses from detectors, and then assign the right-of-way by means of signals, in accordance with traffic demand from instant to instant.



A modification of the traffic control system was needed for operation by trolley cars. The special trolley detector is mounted on the pole at the left. The contactor on the wire is indicated by the black arrow

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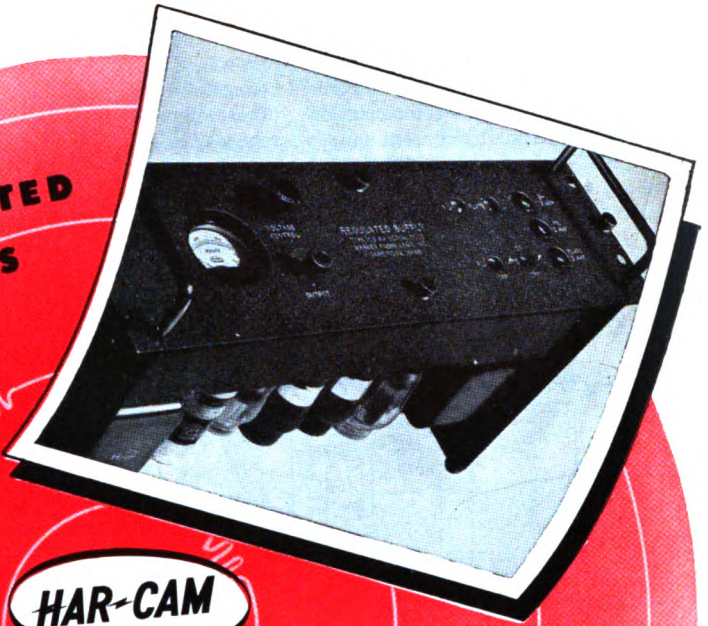

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fied through a vacuum-tube amplifier shown schematically in Fig. 2.

The double-bar type of detector unit is utilized for compensation against operation by current surges in nearby street car rails, power cables, etc., and to insure that the vehicle must pass over some part of the unit to provide operation. This compensation is derived by having the coil assemblies of each of the bars connected in opposition so that, in the event of a nearby current surge acting upon the bars, the voltage generated in one coil will be neutralized by the voltage generated in the other coil.

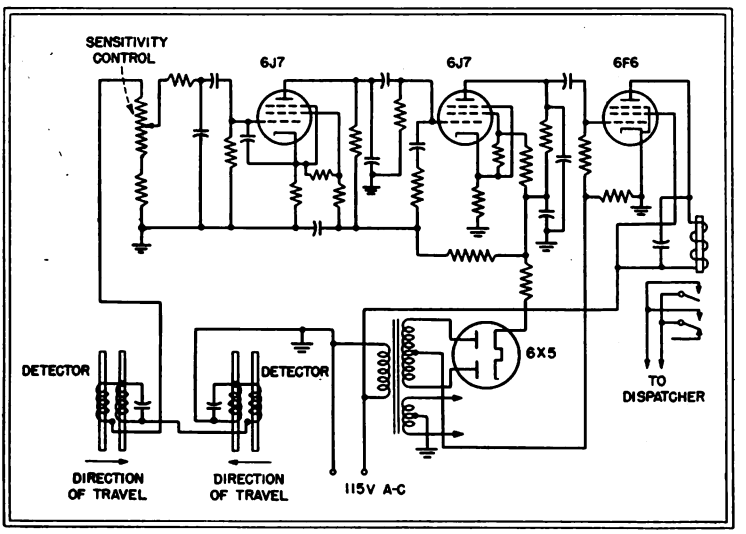

Fig. 2—Pulses from the magnetic detectors are amplified to operate the output relay, indicating a demand for right-of-way to the dispatcher

The amplifier or relay unit itself is only responsive to a positive voltage impulse on the grid of the first tube and it is this feature which makes the detector directional to a certain degree. As it is necessary for a vehicle to be in motion to operate the detector, vehicles which park nearby or directly over the detector do not cause it to be permanently energized and do not affect the normal operation. Other vehicles passing beside the parked vehicle and passing over any part of the bars will be detected.

Operation

When the axle of a vehicle approaches the unit, as shown in Fig. 3, it starts to cut the lines of magnetic force of both bars, thereby inducing a voltage in the coils with current flowing as indicated by the arrows. The coils being normally connected in opposition to each other, only a slight negative voltage reaches the amplifier due to one bar being nearer the axle than the other. As the axle passes over the first bar, the induced voltage in its associated coil reserves. When the axle is traveling between the two bars, the induced voltages in the coils of the two bars are in series and a comparatively large positive voltage impulse is transmitted to the amplifier. As the axle passes over the second bar and away from the detector, the voltage in each of the coils is again neutralized.

With vehicles traveling in the opposite direction, the reverse occurs. A comparatively large negative voltage is generated when the axle is passing between the two bars but, due to the design of the amplifier, this negative voltage impulse is not amplified. However, a car traveling in the wrong direction will generate a small positive voltage on approaching the detector, which voltage may, under certain conditions, be sufficient to operate the relay. To utilize the maximum effectiveness of the directional feature, an adjustable sensitivity control is incorporated in the relay unit and is adjusted manually by a knob on the panel of the unit. This control is adjusted to the minimum point where all vehicles approaching the intersection from the correct direction are detected.

The dispatcher mechanism is mounted in a weather-proof cabinet equipped with numbered connecting blocks and suitably labeled switches for switching on or off of the traffic lights and transferring from automatic to manual control as desired. It consists of a solenoid-operated cam shaft having six steps per cycle.

Associated with the cams are two groups of spring contacts which open or close in varying combinations according to shaft position, to set up the appropriate signal indications and to change the timing conditions as necessary. Four relays, two gas discharge tubes, a transformer and rectifier and several R-C timing circuits are also included in the dispatcher unit. The transformer furnishes the low a-c potential for the operation of the detector relays and, in conjunction with the rectifier tube, furnishes d-c for the timing circuits.

Traffic cycles of the control mechanism are divided into six intervals which consist of an initial green or go interval, a vehicle green interval and a yellow caution interval for each of two phases. The length of

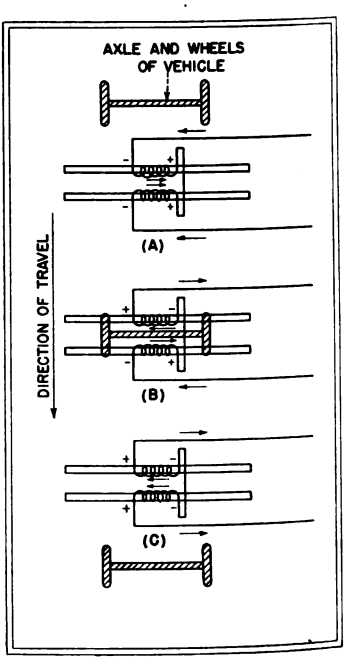

Fig. 3—Axles of moving vehicles cut magnetic lines of force, generating voltages in the inductors

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Answers to your Questions about the SHURE "556" *Super-Cardioid Broadcast Dynamic*

Q. *What is meant by Super-Cardioid?*

Answer: Super-Cardioid is an improvement on the cardioid (heart-shaped) pickup pattern, which makes it even more unidirectional. "Super-Cardioid" reduces pickup of random noises by 73% as compared to 67% for the Cardioid, and yet has a wide pickup angle across the front.

Q. *To accomplish this, is it necessary to have two Microphones in a single case?*

Answer: No. The Shure "556" is designed according to the "Uniphase" principle, a patented Shure development which makes it possible to obtain the "Super-Cardioid" pattern in a single compact, rugged unit.

Q. *Over what range does the Shure "556" give quality reproduction?*

Answer: The Shure "556" provides a high degree of directivity, both horizontally and vertically over a wide frequency range from 40 to 10,000 cycles.

Q. *Does the Shure "556" reduce feedback?*

Answer: Yes! Reflected sounds and "spill-over" from loud speakers entering from the rear are cancelled out within the Microphone.

Q. *Can the Shure "556" be used outdoors?*

Answer: Yes. It is insensitive to wind and will withstand heat and humidity. The low impedance models may be used at practically unlimited distances from the amplifier.

Q. *Can the Shure "556" be used for Studio Broadcasting?*

Answer: More than 750 Radio Broadcast Stations in the United States and Canada use the Shure "556" in their studios. Because it can be placed with its back to the wall without picking up reflected sounds or echoes, it facilitates Microphone placement.

Model 556A for 35-50 Ohm circuits—
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each interval is determined by the setting of a variable resistor in an R-C circuit. Charging the capacitor through the resistor continues until sufficient voltage is developed across the capacitor to cause the gas discharge tube to flash over, energizing the cam-shaft solenoid to shift the cam assembly one step. As the cam shaft is rotated from step to step, a new R-C combination is switched into the circuit, making possible individual adjustments of each time interval.

Trolley Cars

Difficulty arose in the operation of the system close to electric trolley lines. Consider the operation when the trolley car arrives at an intersection and stops to receive or discharge passengers. Since the traffic detectors are placed some distance from the intersection, the halted trolley cars are now past the detector and there is no way of signaling the traffic dispatcher when the car is ready to proceed. The most economical method is to place a contactor on the trolley wire so that a movement, a few feet forward, of the car will close the contact and register a demand on the dispatcher.

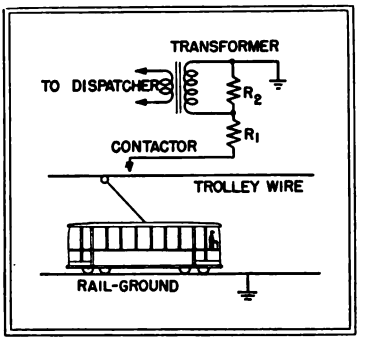


Fig. 4—Trolley closes contactor, generating voltage impulse in transformer to actuate despatcher

The first solution, involving the use of a contactor and a relay, had several disadvantages. A modification shown in Fig. 4, eliminated the disadvantages of the first idea. As the trolley moves forward, it closes the circuit to ground through the trolley pick-up unit, impressing what is in effect a unit step voltage on the transformer. The transformer isolates the dispatcher circuit from the d-c of the trolley line, but passes on the necessary impulse to register a demand for right-of-way. The voltage—divided network of R_1 and R_2, by limiting the voltage applied to the transformer primary, permits control of the intensity of the secondary pulse.

A voltage-divider network, substituting a capacitor for R_1, was considered. This arrangement, while removing all d-c from the transformer, had the disadvantage of placing high transient voltages on the circuit, making necessary special insulation on both the transformer and R_2.

Two other considerations involved secondary impedance and false operation due to transients in the trolley conductor field. Since the detectors are wired in series, it is necessary that the impedance looking into the secondaries of the individual units be low. A humbucking and shielded transformer eliminates the effect of unwanted transients.

Penicillin Drying Machine in Production

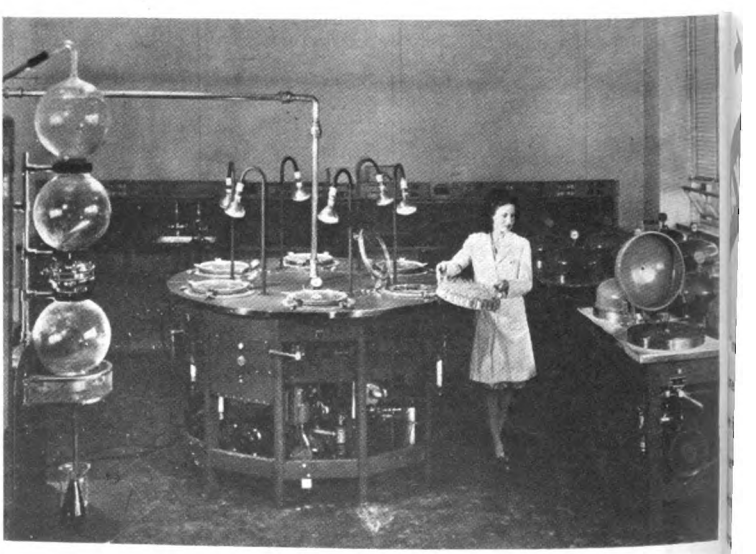
AS NOW PERFECTED for production use, the electronic drying system for penicillin that was announced by RCA Laboratories last fall can produce ready-to-use vials of penicillin at the rate of 2,000 per hour, with each vial containing 100,000 Oxford units of the renowned drug. Hourly production is sufficient to treat 400 patients requiring 500,000 units each. The system can operate as much as 20 hours a day for a total of 4,000,000,000 Oxford units.

This rate of output exceeds that of conventional equipment which occupies four times the floor space and costs triple the amount of the electronic system, according to officials of F. J. Stokes Machine Company, manufacturer of the system developed by RCA Laboratories. Cost of operation and maintenance of the electronic system fall far below that of conventional equipment.

Three Units

The system was developed by Dr. George H. Brown and his associates, C. N. Hoyler and R. A. Bierwirth, of RCA Laboratories, and consists of a bulk-reducer for dehydration, an electronic vacuum drier, and vacuum heating chambers that remove the last bit of moisture from the vials.

The bulk-reducer employs r-f current to concentrate the penicillin



Complete electronic drying system for penicillin. The three glass bulbs comprise the r-f heating bulk reducer that does in 30 minutes a dehydrating operation that would rquire 24 hours by freeze-drying. At center is the electronic vacuum drier that reduces 1-cc quantities of concentrated penicillin solution to a dry film in vials. At right are the dome heating tables where the last bit of moisture is removed from the vials

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solution to a constituency 000 Oford units per cubi menter. A standard RC watt r-f generator is conne provide dielectric heating contents of three large glass joined in vertical series attached to a pump that mai a relatively low vacuum. I vacuum, the solution boils a Evaporation takes place at of three litres an hour, a times as fast as by conv means.

Second Generator

The electronic vacuum dr sists of six porthole-frame chambers mounted on a table and connected to a RCA 2,000-watt r-f ge Vials containing 1 cc of trated penicillin are placed chambers and caused to individually at 3,000 rpm, subjected to r-f heating. In minutes, the solution in the becomes a dry film.

Each chamber in the elec vacuum drier contain 34 of concentrated penicillin sol and the system is so regulate r-f heat penetrates three vacuum chambers at one time ing the other three free for ing and unloading. Red, gree amber lights at the side of chamber informs the operat progress.

To eliminate the small per age of moisture that lingers i dried penicillin, the vials placed in electrically heated va chambers for 30 minutes.

Continuous production is vided at a fixed rate of speed may be started or stopped at without endangering the under process. Development is being continued to extend application of the electronic ing process to many other prod such as foods, antitoxins, biol cals, and pharmaceuticals.

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IN CERTAIN DEPARTMENTS of B. F. Goodrich plant in Ak Ohio, industrial inspectors re directly to workers involved using an intercommunicator s

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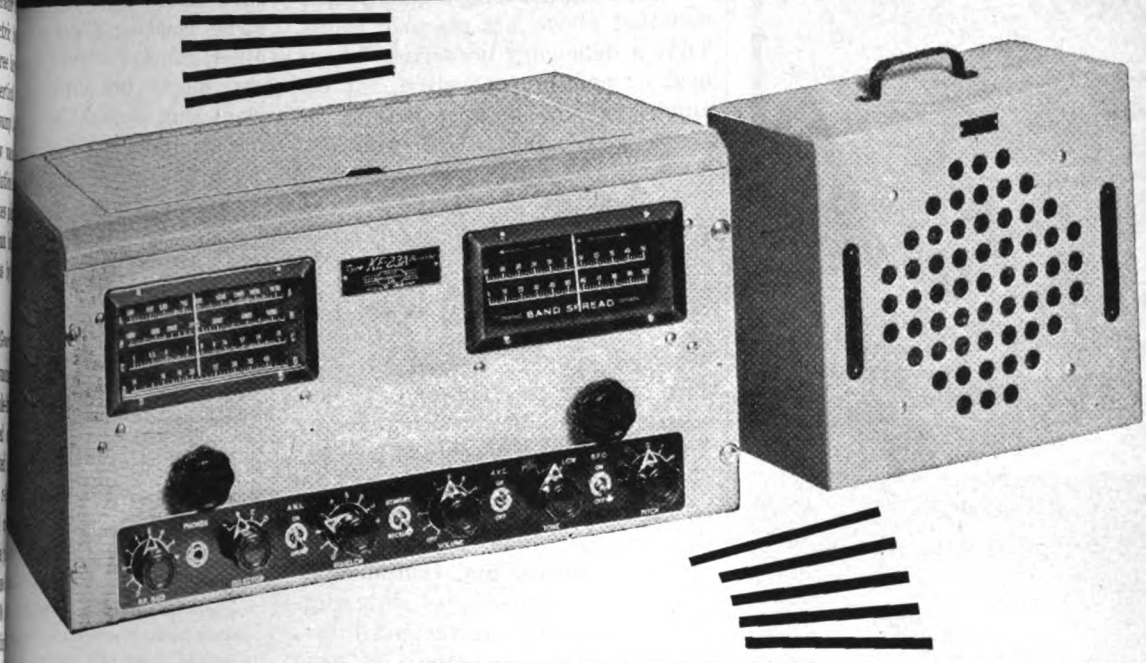
UP TO 42 Mc



DOWN TO 500 Kc

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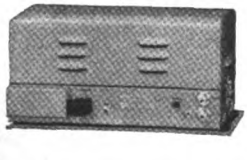

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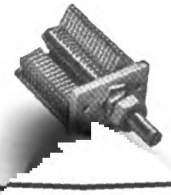

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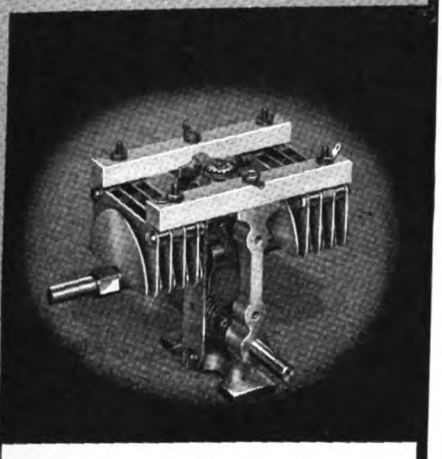
Application



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tem. Seated before a microphone, the inspector can reach up and pull a callboard lever to contact the responsible worker over a loudspeaker mounted above his place of work. Thus a deficiency occurring in one heat or molding operation, for example, can be spotted before the error is repeated. The workman can answer by pressing a button.

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Production Tester for Small Values of Capacit...

By L. Y. HANOPOL
Technical Apparatus Co.
Boston, Mass.

THE QUALITY CONTROL and the uniformity of production demanded by present military needs has brought into effect standards set by the RMA and the Joint Army-Navy Committee, which have required greater accuracy and reproducibility of measurement of interelectrode capacitance of vacuum tubes. With the encouragement of some members of the tube industry, the design of an instrument for measuring the interelectrode capacitance of vacuum tubes was undertaken. An instrument of this type had been developed and used successfully for some time at Raytheon Manufacturing Co., whose data

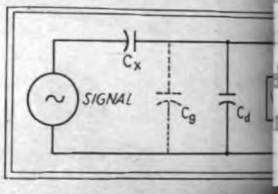

Fig. 1—Basic circuit of the vacu... capacitance meter. C_x is the ... itance being measured, C_d the u... element of the network, and C_g ... pacitance to ground for the ... being measured

were released to provide th... for commercial redesign of ... strument to permit its mo... eral use by the industry.

This instrument most ... filled the requirements desir...

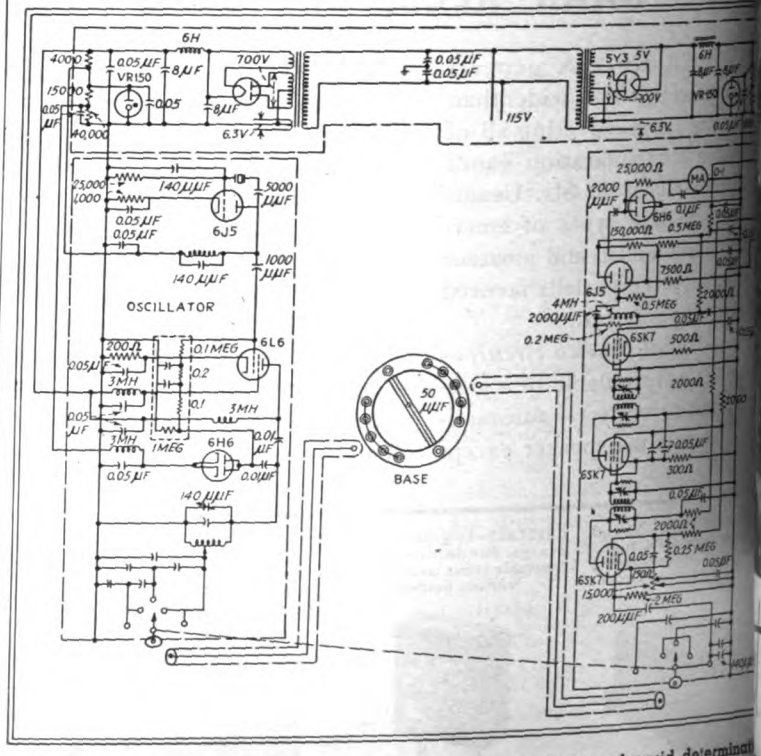

Fig. 2—Complete circuit of the capacitance meter for simple and rapid determinat... of very small values of capacitance

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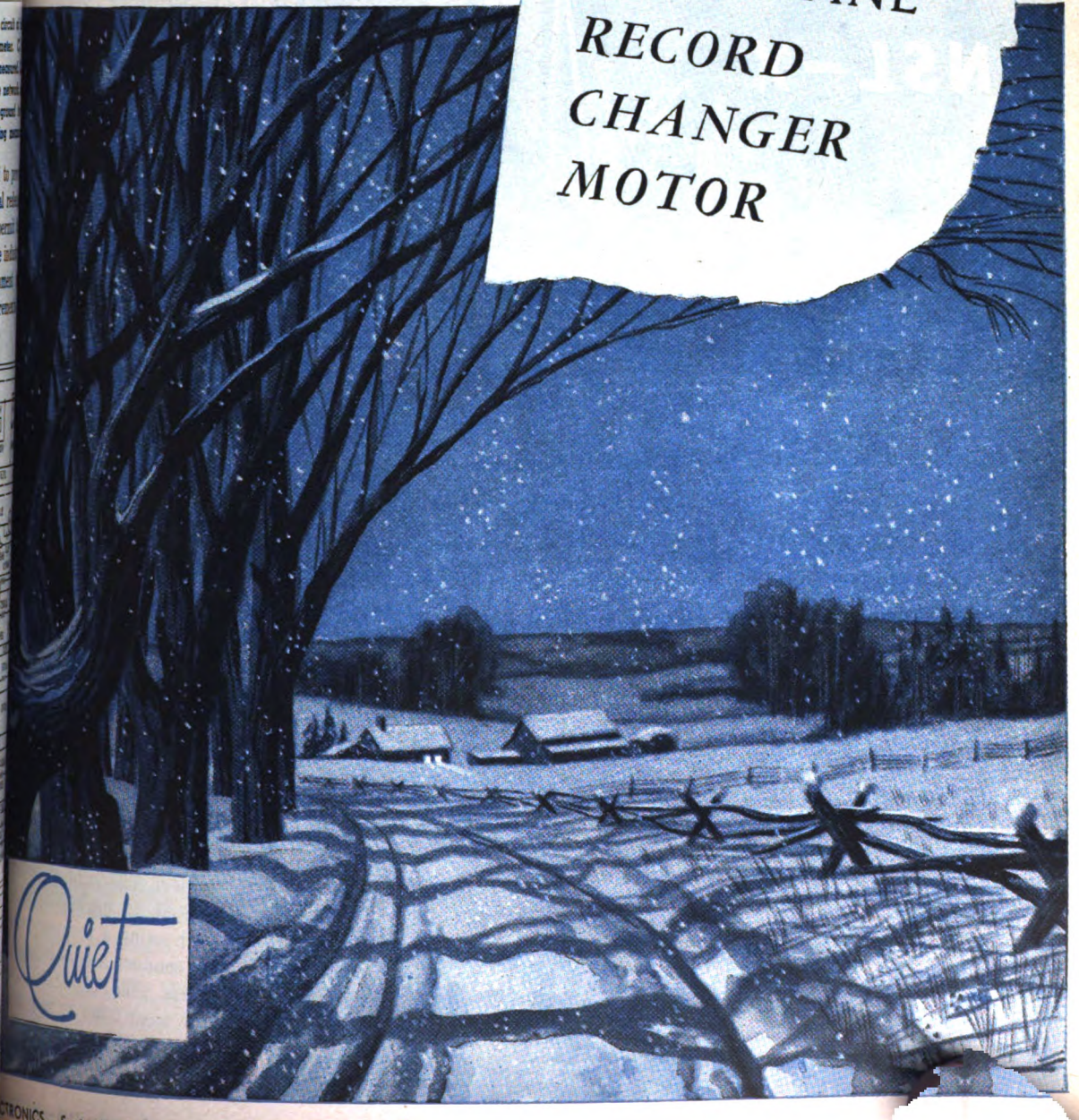

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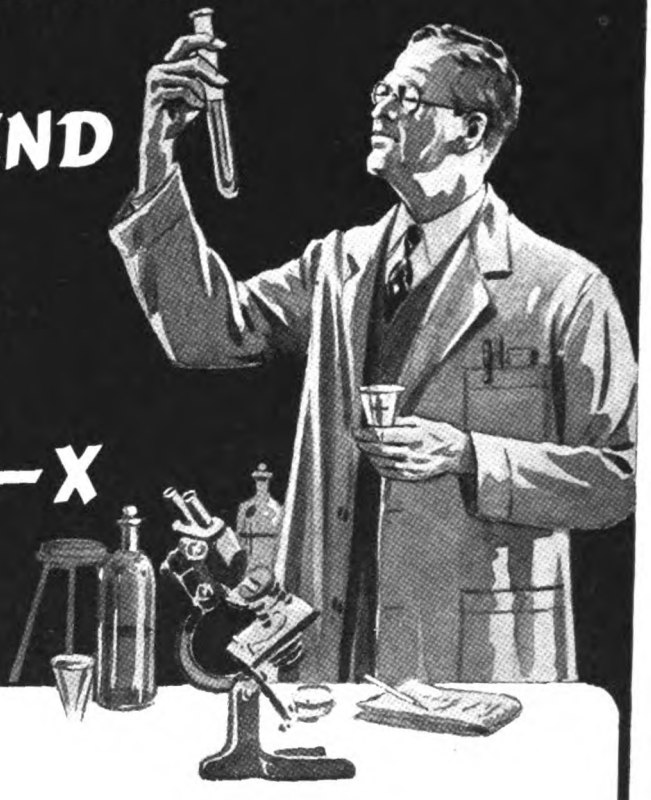

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half of one percent readi
able, a range multiplier
be voltage calibrated,
reading capacitance ind

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ure other capacitances
between vacuum-tube e
adequate measurements
tained without shielding
specimen when its geome
terminate and the samp
directly connected to the
coaxial cables. Not only
such as small fixed and va
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sirable.

Principle of Operat

The circuit of the inst
shown in Fig. 1. When
known C_s is part of a
vider whose other elem
the voltage across C_s will
tional to C_s. The system
quires only a constant
source and a high-impe
tector. Variation of range
uring is controlled by the
of the oscillator voltage an
viding elements of the
network.

There are two limiting
error: first, that due to the
ance of the unknown: an
the capacitance to grou
unknown, which chang
of C_s, the other ele
divider. The conductance
reduced to negligible
by choosing a frequency
the conductance-to-reactan
is less than 0.01. Measu
show most tubes to have
between 100 and 200 at
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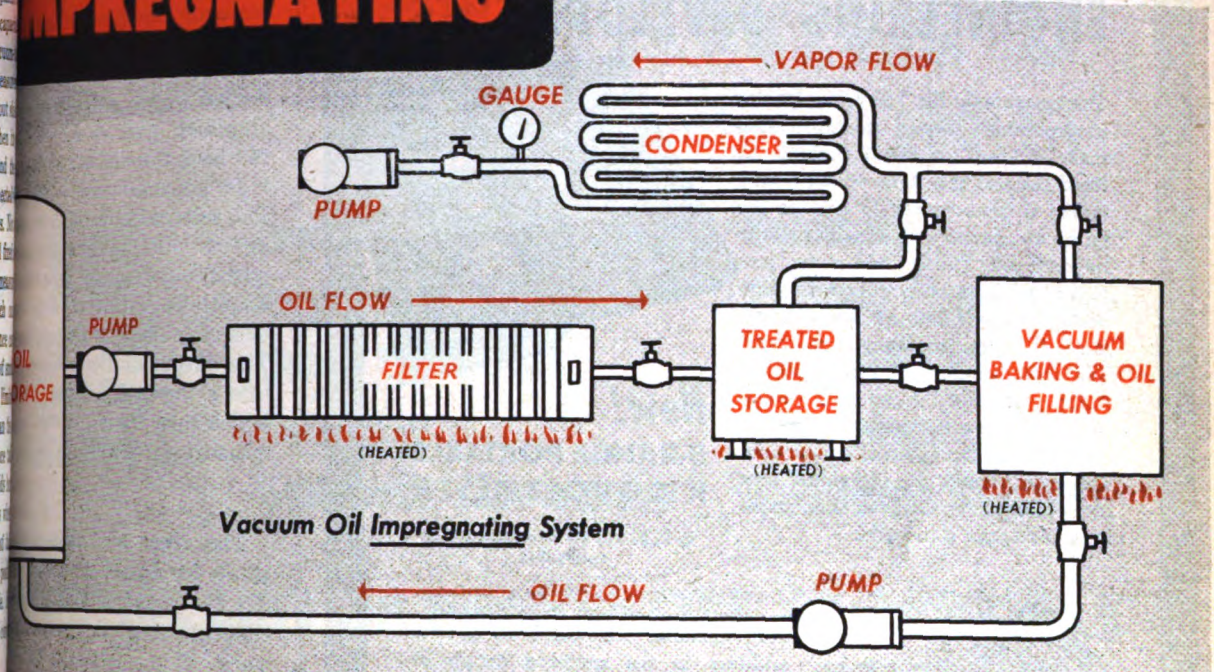

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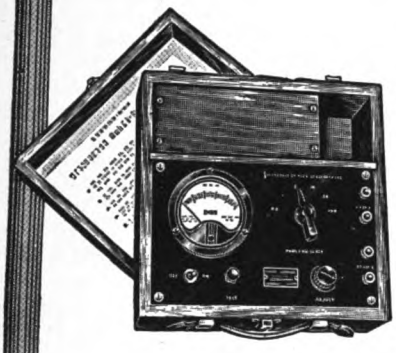

Milliohmmeter No. 673-F is a new addition to the growing group of Shallcross direct reading resistance measuring test sets. Linear scales eliminate crowding of the higher resistance values at one end of the scale. Six scales have ranges of 0-0.5-1-5-10-50 and 100 ohms full scale, thus bridging the gap between the regular Shallcross Milliohmmeters that are extensively used for low resistance testing and the ordinary Ohmmeters used for relatively high resistance measurements. Separate connections are provided for current and potential to minimize the effect of lead and contact resistance when measuring low values. The instrument uses a single #6 dry cell battery carried in a compartment.

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The instrument built alon
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oscillator, vacuum-tube vo
and shielded junction block
sociated tube adapters. Th
supply unit is fed by a volt
ulating transformer and co
separate supplies for the v
oscillator.

The oscillator is a crys
trolled Pierce stage driving
amplifier, part of whose ou
fed back through a rectifier
vide automatic amplitude
The voltage source is thus st
against line voltage chang
quency drift, and output
amplitude variation arisin
detuning and switching o
The output of the oscillato
into a three-step decade att
which then feeds the voltag
measuring network.

Details

The vtvm is a high-gain,
stage band-pass amplifier,
put of which contains the d
elements C_d of the measuri
work. This amplifier is follo
an impedance-changing tube
drives the 1-ma, six-inch ind
meter through a rectifier.
protection is provided by the

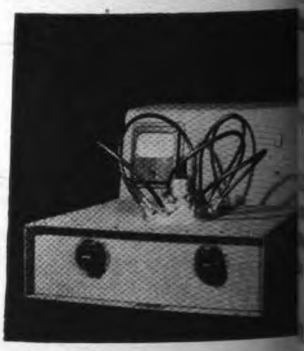

**Fig. 3—Capacitance meter in use, s
ing a typical arrangement of cable
interelectrode capacitance measure**

overload characteristic, which
the meter current from exce
2.3 ma for any value of input
age. The range selector is a s
control driving the attenuator
the divider switches which
linked by a gear and rack driv

Calibration of attenuator ste
accomplished by supplying volt
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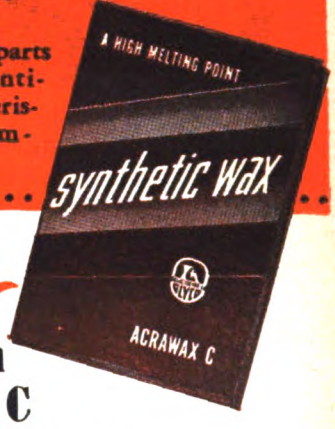

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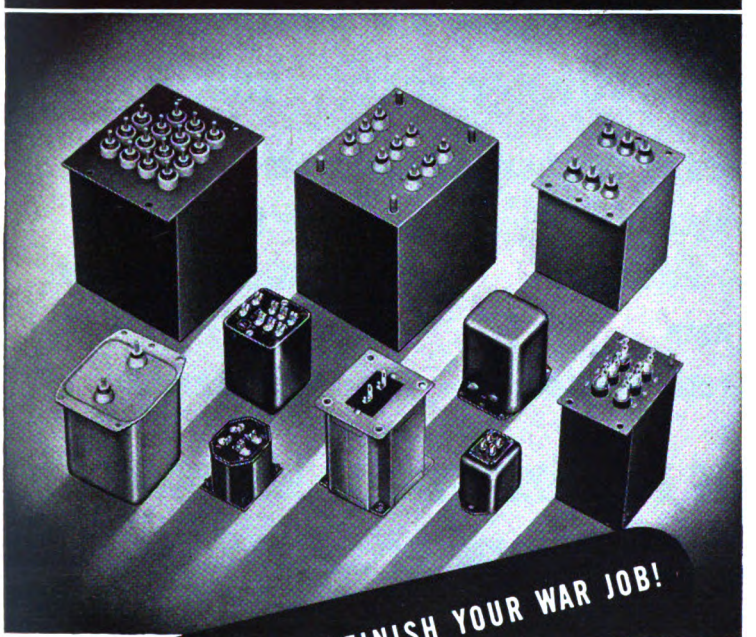

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method has two primary advantages; first, the calibration can be made against a single accurate standard of capacitance, thus obviating the need for extremely low capacitance standards which are difficult to obtain; and second, the remaining ranges can be calibrated as voltage decades from the first range. The procedure includes loading the fixed divider elements with capacitance of the order of magnitude of that introduced by tubes being measured, which provides a central value for positive and negative errors, thus doubling the value of tolerable capacitance to ground, within the assigned limits of error.

The average of a number of these instruments has indicated that limits of error are less than 3 percent, a part of which might be attributed to variations in shielding rather than to absolute error.

Special Adapters

The standards of shielding set by the Joint Army-Navy and RMA committees have been related to external tube shields and their relationship to tube elements. The various measuring methods used have had more or less completely shielded sockets and various devices for the subtraction of residual capacitances, some of which can be shown to vary with the tube in and out of

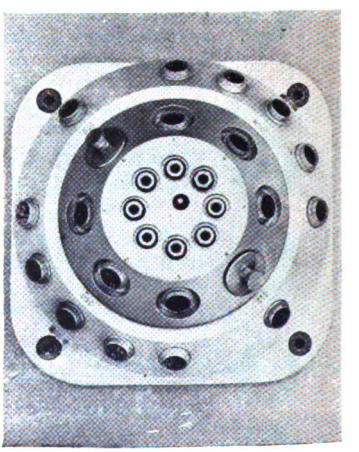

Fig. 4—Close-up view of the base into which socket adapters are plugged. The parallel banks of receptacles are used for oscillator and vtvm connections

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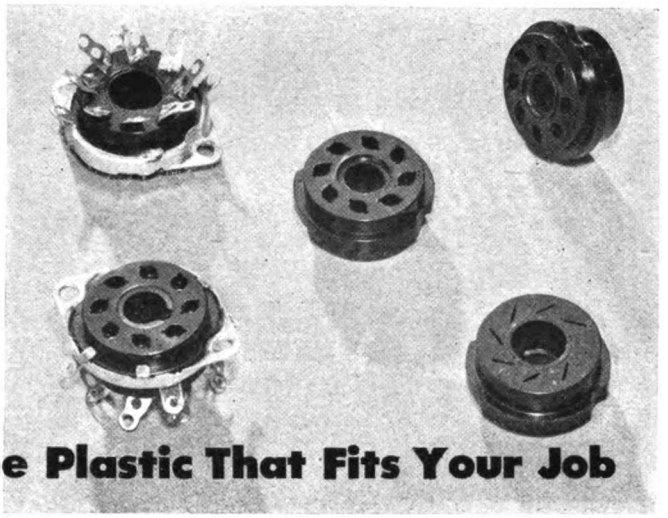

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During the past five years the plastics industry has grown by leaps and bounds so that today you find plastics being used extensively throughout practically all fields of business. Because they are the most versatile, the phenolics are the most widely used of all plastics. As specialists in the production of phenolics for the past quarter century, Durez makes the natural starting point for selecting the plastic that fits your job.

Typical of thousands of progressive concerns is National Fabricated Products—molders of the octal radio tube sockets illustrated. This company is well known for many outstanding contributions to the communications field and, like so many of America's manufacturers, has found the unusual versatility of Durez phenolic molding compounds of unusual value in developing complex products.

Octal Sockets

For example, these octal sockets were molded from a high-dielectric Durez compound which provides a high-voltage breakdown safety factor as well as excellent tensile strength and low moisture absorption under humid operating conditions.

Designed to use a minimum amount of chassis space, these octal sockets have self-aligning contacts which float in the molded Durez insulation and provide the necessary safeguards against fracture of the glass seal of the radio tube resulting from possible misalignment of tube pins. The exact tolerances and superb quality of the finished products attest the ingenious molding job done by National Fabricated Products and the versatility of the Durez phenolic molding compound used.

Unusually Versatile Material

Like the material used in molding these octal sockets, the more than 300 other Durez molding compounds possess many highly desirable inherent characteristics which make them extremely valuable to the imaginative design engineer. Such properties as dielectric strength, excellent moldability, highest dimensional stability, and resistance to heat, moisture, and chemicals—to mention a few—are common denominators of all Durez compounds . . . make the logical starting point in the search for the plastic that fits your job.

Expert Assistance Available

The background of Durez technicians includes active participation in the successful development of many and varied products on a scope that is practically all-embracing.

The benefits which this experience and a wealth of proved product development data can provide are available to you and your custom molder towards helping select the plastic that fits your job. Durez Plastics & Chemicals, Inc., 329 Walck Road, N. Tonawanda, N.Y.

PLASTICS THAT FIT THE JOB

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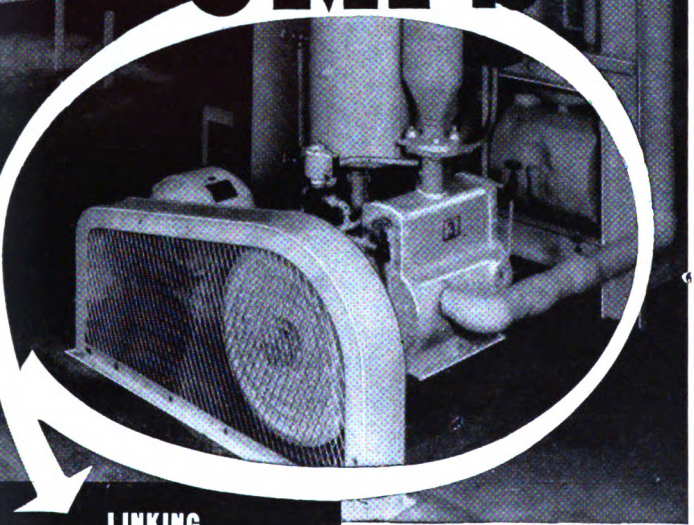

LINKING LABORATORY PROCESSING AND PRACTICAL ARGE SCALE MANUFACTURE

National Research Corp. installation of vacuum diffusion process dehydration equipment using Kinney Vacuum Pumps at Old Quaker, Penicillin Plant, Schenly Distilleries, Inc.

INNEY VACUUM PUMPS have brought into large scale production many vital products that only yesterday were laboratory curiosi-

The exceptional performance of these pumps, has, in fact, per-ed the entire redesign of several plants to give much greater pro-ion and better products. Thousands of KINNEY High Vacuum ps are maintaining the low absolute pressures required in making tronic products, in sintering alloy metals, coating lenses, producing d plasma and penicillin and aiding the production of countless other lucts. Proved and dependable, KINNEY Single Stage Vacuum ps maintain low absolute pressures to 10 microns; KINNEY Com-nd Vacuum Pumps to 0.5 micron or better. Write for information.

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the socket. These sources of variation are eliminated by use of an adapter each of whose contacts is in a separate, completely shielded compartment. A set of such adapters has been designed as part of the equipment.

The adapters plug into a universal shielded socket, having all the pin contacts carried through shielded chambers to a series of receptacles mounted on an inclined periphery of the socket. This socket is in turn mounted upon and shielded from a casting whose periphery carries two banks of parallel-connected receptacles. Each bank is shielded; one bank connects to the oscillator and the other to the vtvm. Patch cords between the lower banks of receptacles and the receptacles in the socket serve to connect the tube elements into the measuring circuit in any arrangement required. The base casting also contains a 50-$\mu\mu$f standard capacitor.

The efficacy of the adapter shielding is shown by the fact that the capacitance between any unused contact and a pin plugged into an adjacent contact, and projecting

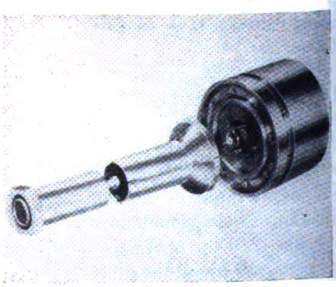

Fig. 5—Special socket adapter with shield and terminal connector for acorn tube

two inches above the top plate, is less than 0.00005 $\mu\mu$f when the whole is shielded. Interchanging of adapters does not affect the reproducibility of measurements.

The instrument is readily operated, the controls being merely those for range and calibration. The gain of the vtvm is set, with the standard in place of the unknown, for a meter reading of 0.5. The tube elements are then connected so that the unknown capacitance is between the vtvm and oscillator circuits. The shield is

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grounded or connected as required by the ap specification.

The capacitance betw elements being measu product of the meter r the multiplier dial setti event that any of the r upon the low end of th greater accuracy is re range of the instrument ied by changing the point; that is, calibratin stead of at 0.5 provide ranges of 50, 5, 0.5, 0.05 $\mu\mu$f; calibration at 0.2 full scale ranges of 200, and 0.02 $\mu\mu$f. For prod ing, other points of calib be selected so that the measurement fall on a s for one range setting.

The assistance of Gowell, of the Raytheon turing Company, has project possible.

BIBLIOGRAPHY

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• • •

Controlling Activatio Schedules At Exhaust

BY M. SILVERMAN,
Production Manager, Cathode-ray Tube Divisi North American Philips Comp Dobbs Ferry, N. Y.

ENGINEERS SEEM to have a changing schedules—and at times become very trou to those charged with the of maintaining maximum tion.

After two years of exper tion in our exhaust depart standard activation schedu evolved. With only slight tions, this system is applic almost every type of cath tube produced. Table I sho basic schedule that was adop

Engineers of Philips and Clock Company collaborated sign and build a timer using

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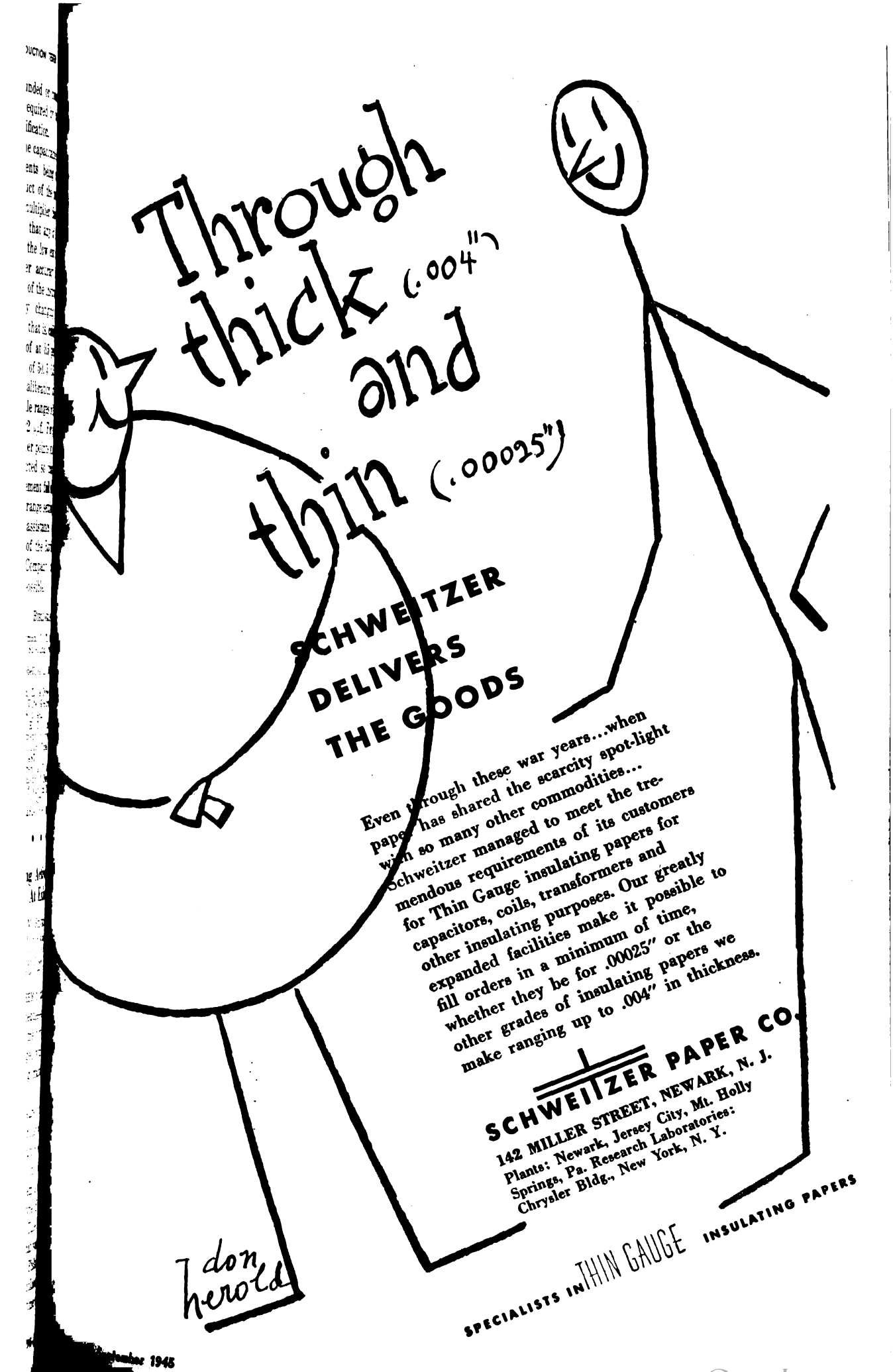

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20 seconds of time. T

TABLE I—EXHAUST S
OPERATION

Step
1 Place tube in compression fitt
2 Open pump at stop-cock.
3 Check for leaks.
4 Light oven.
5 After tubes have cleared of aspirator switch and lower ov
6 Bake for 35 minutes at 400 C. period, manifold should be cl
7 Raise oven half way and shut
8 Bombard mount to dull red. and pause between tubes.
9 Light heaters at 8v—2 minutes.
10 Light heaters at 9v—4 minutes.
11 Light heaters at 10½v — 3 min grids.
12 Connect all elements excep cathode to d-c and slowly ra 50v—6 minutes.
13 Lower heater voltage to 9v; l and flash getters 5 minutes.
14 Tip off.

NOTE: Timer controls steps 8 t schedule.

be inserted in the slots o
The shorter rod snaps
activated switch to the
and the longer rod turns
off. By correctly positi
rods, it is possible, in o
tion, to open and close fi
in any desired sequence
chosen time intervals.

The complete circuit is
Fig. 1. Here is the way
works on a typical exhaust

Step 1—Switch 1 is cl
ually. This starts the m

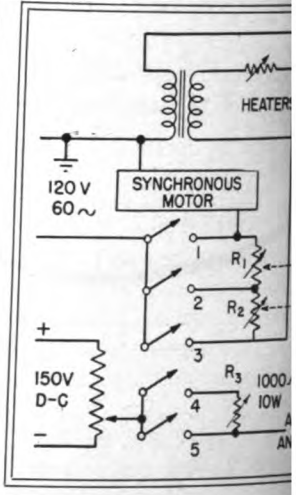

FIG. 1—Circuit diagram of au
exhaust schedule timer

lights the tube heaters.
passes through two variab
sistors in the primary, ea
justed to lower the heater
by some set value. The initia
age on heaters is adjusted by

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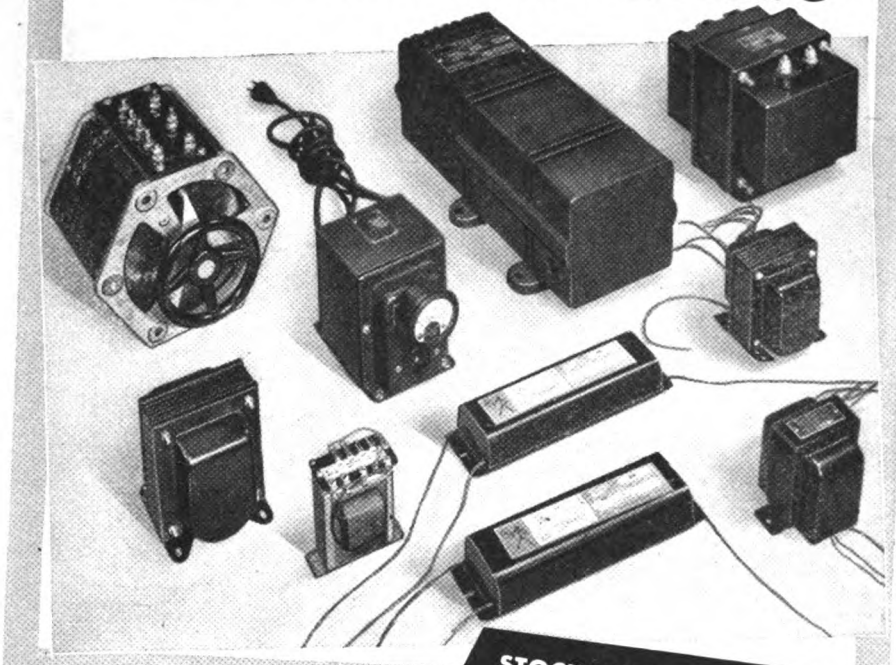

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sistor in the sec
Step 2—Switc
shorts out resis
the heater voltag
Step 3—Switch
ing out resisto
heater voltage 1½
Step 4—Switc
volts d-c is app
anodes.
Step 5—Switc
has no immediat
sistor R_3 is shorte
Step 6—Switch
This throws in r
drops the d-c vol
and resistor R_2 w
heater voltage to 9
Step 7—Switche
turning everythin

Empty

The heaters of
hausted are conne
If the number of t
is the same, the c
not vary significan

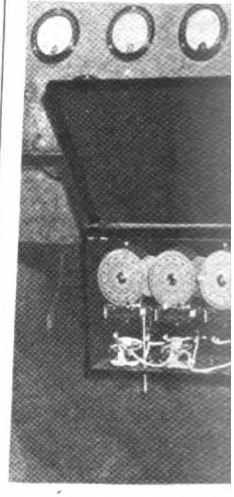

FIG. 2—Automatic tim
switch five circuits t
choice of sequence an

load. When runs v
(having the same res
hot heater) are conn
of missing tubes. T
identical load conditi
Resistors R_1 and R_2
to produce 1 and 1½-v
spectively, in the seco
once the starting volta
timer will increase h
in 1 and 1½-volt steps.
is set to cause a 40-vol
The timer has been

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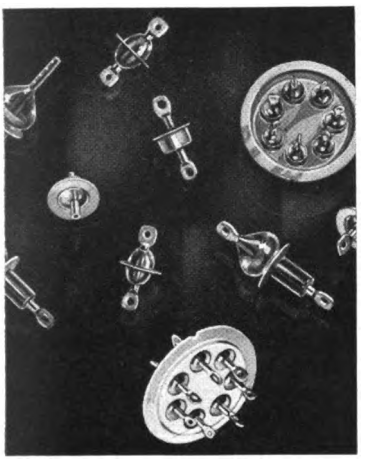

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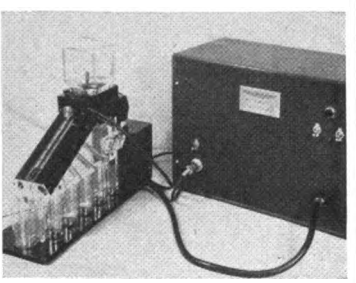

Complete equipment of the ball-sorting gage developed by Jack and Heintz engineers

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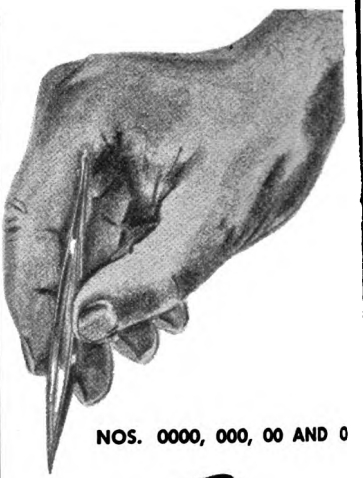
Electronic Swallow Counter

DEVELOPMENT OF THE tympanometer by the Westinghouse Research Laboratories, to determine the ease or difficulty of compensation of a flier for changes in altitude by accurately counting his swallows, has obviated the necessity of the physi-



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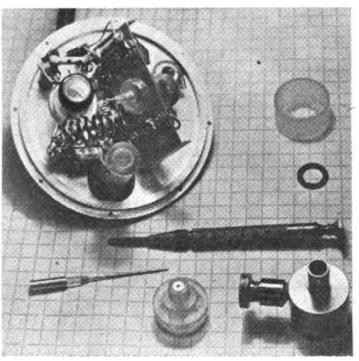
cian remaining in the high-altitude chamber during a test.

The instrument is constructed in the form of oversize earphones that clamp over the flier's head, an earpiece over each ear, and the swallows are automatically registered and recorded on a chart outside the chamber.

Each earphone contains a microwave transmitter with a short antenna. Fluid-filled chambers placed against each ear drum of the subject transmit the pressure caused



The microwave transmitter and accessories of the tympanometer for checking airworthiness of prospective fliers by counting his swallows

by a swallow to a diaphragm in the earphone. Movement of a pin attached to the diaphragm produces a peak in the output wave of the transmitter. Because the walls of high-altitude the chamber are metal, the receiving antenna is strung inside and the received signals are carried by a coaxial cable to the recording apparatus outside.

Both voluntary and involuntary compensations as related to movement of the ear drum and the rate of response of these to outside pressure variations are shown by the tympanometer. Graphs of the number of swallows, plotted against altitude or pressure, are made for use by the doctor without his presence in the chamber being necessary.

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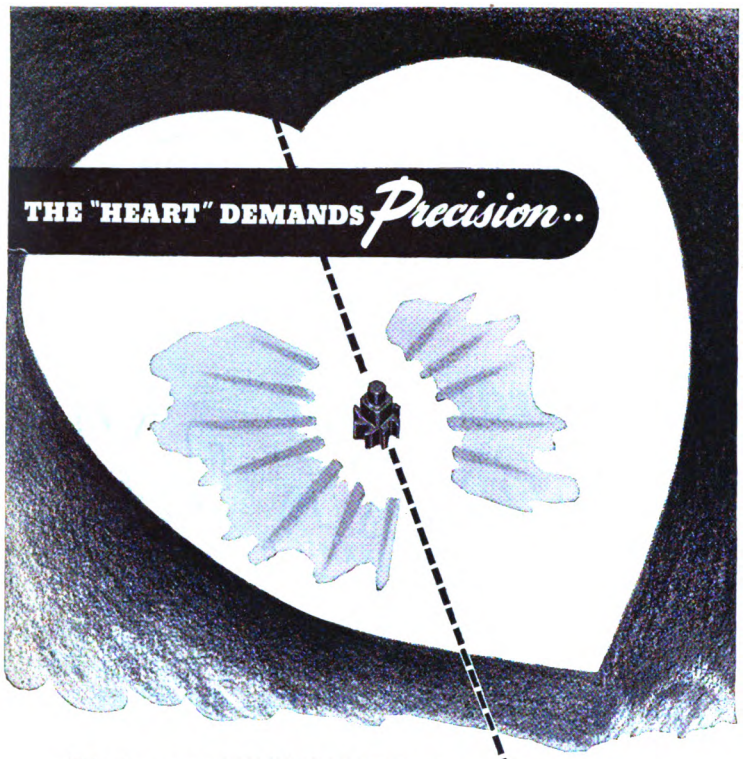

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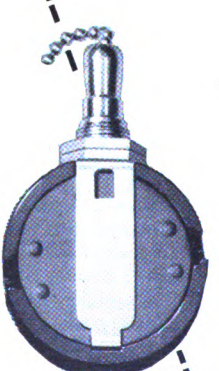

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use in industry for time-motion studies of extremely high-speed subjects. The unit was originally developed by photographic engineers of the Air Technical Service Command at Wright Field, as a means of studying the effects of gunfire on armor plating. It permits taking six photographs of a 0.50 caliber bullet while it moves half its own length.

The timer synchronizes six microflash lamps so that they may be fired either in train or simultaneously. This is accomplished by utilizing linear charging of a capacitor through a pentode tube. The voltage rise across the capacitor is applied to six amplifiers which are arranged to have progressively decreased sensitivity. As the voltage rises, each amplifier is tripped in turn and the lamp to which it is connected is flashed.

This enables timing of pictures exactly, for by setting dials the operator can space the six lamps so that it takes 0.6 second for all six pictures, the slowest rate, or as little as 0.0003 second at highest speed.

Increased Range

The photographic engineering branch of the ATSC laboratory received six of the first microflash lamps ever built about a year ago. They were a development of Harold E. Edgerton of MIT. By conservative measurement, each lamp flashes in approximately 0.000002 second. They were built originally for work with small, high-speed parts at ranges of six to eight feet but ATSC photo engineers increased the range to 40 to 50 feet by using x-ray film, an *f*/2.5 night aerial camera lens and concentrated developer.

Taking pictures with the microflash units consists of opening the camera shutter in darkness, flashing the lamps and closing the shutter. The lamps may be triggered either by sounds which react in microphones, by electrical impulse transmitted by electrical circuits, such as in propeller rupture studies where the exact moment of rupture cannot be predetermined, or by light reacting on a photo tube.

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MASTER audiodiscs

The excellence and consistent quality of Master Audiodiscs gained wide acceptance for them prior to the war. Now, the demand for these recording blanks, from which pressings are made, has increased more than fourfold. And here are a few of the reasons:

1. They give fine results with either the gold sputtering or silvering process.
2. Like regular Audiodiscs, the thread throws well, and there is no annoying static.
3. Cut under good recording conditions there is no audible "background scratch".
4. It is easy to ship them safely from recording studio to processor.
5. Especially important—there is no increase in surface noise from recording time to processing—be it a few minutes or many months.

Master AUDIODISCS are manufactured in three sizes on stretcher leveled No. 2 aluminum recording sheet—12", 13¼" and 17¼" for 10", 12" and 16" pressings.

AUDIO DEVICES, INC.

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they speak for themselves **audiodiscs**

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TUBES AT WORK

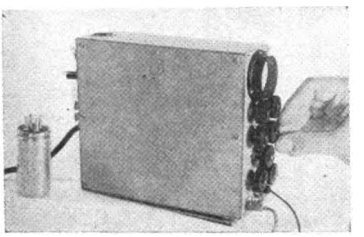
Midget CRO for Maintenance Technicians 202
VHF Omnidirectional Radio Ranges 206
Use of Shunt Diode for Supplying Bias Voltage 218
Popular Radar Tube Made in America 230

Midget CRO for Maintenance Technicians

FEATURES OF A MIDGET oscilloscope developed in England provide the kind of operation that appeals to men who are called upon to service industrial electronic equipment in several plants, each having a different power-line voltage or frequency. In addition, the instrument may be operated in the field, on aircraft, or on small boats by the use of a 12-volt battery. Total power consumption is only 15 watts whether battery or line operated.

The instrument contains a 1½-in. cathode-ray tube, linear time base, signal amplifier, and power supply and is called the Miniscope by General Electric Ltd. The complete schematic of the unit is shown in Fig. 1.

The focal properties of the small tube are reported excellent and give good definition. Brilliance and focusing controls are provided and external signals may be applied to the grid of the tube for intensity modulation. Direct access to the *X* and *Y* plates is also possible. Brilliance modulation is very useful in the examination of transients, when normal brightness obtainable would



Midget controls and a 1½-in. c-r tube permit the Miniscope panel to be only two inches wide

prove to be insufficient for the high writing speeds involved. The sensitivity of the *X* plates is 4.0 volts/mm and the *Y* plates 4.5 volts/mm. The input capacitances are about 20 $\mu\mu$f and the input resistances 3.3 megohms.

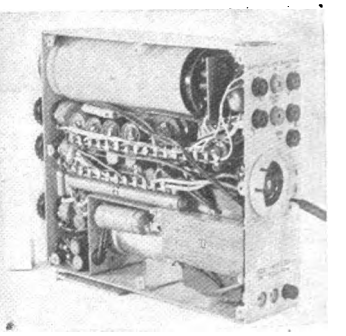
The circuit provides a time base with a frequency range of 20 to 25,000 cps for the linear horizontal sweep. Synchronization may be derived from either the observed signal, the a-c line, or any other external source.

Vertical Amplifier

The single-stage resistance-capacitance coupled amplifier uses a pentode tube and is of the usual design. The gain is continuously variable by means of the input potentiometer *G* and has a maximum value of about 400. Response is essentially flat from 50 to 10,000 cps and waveforms of only 0.1 volt can be easily examined. A separate attenuator is provided to reduce signals which are too large for direct application to the deflector plates.

The instrument is designed for operation from a 12-volt battery and contains an internal vibrator. The total power consumption is then 15 watts, the same as when the a-c line is used. This provision of battery operation makes the equipment versatile for industrial applications, in the field, aircraft, and small boats. For many wartime applications the Miniscope has proved invaluable.

High voltage is obtained from two metal rectifiers in a voltage-doubler circuit and a single source is used for the cathode-ray tube, time base and amplifier, resulting in a great saving of weight.



Compact construction of the Miniscope. The rear panel contains the input jacks and a socket for the vibrator

The internal construction of the instrument is shown.

A socket on the top of the case makes the A and B supplies available from the power pack to operate small external units which may be designed to fit on top of the instrument. This idea of providing small plug-in units for particular requirements is analogous to the interchangeable lenses of miniature cameras and enables the oscilloscope to be adapted for a vast range of uses.

Another attachment is a green

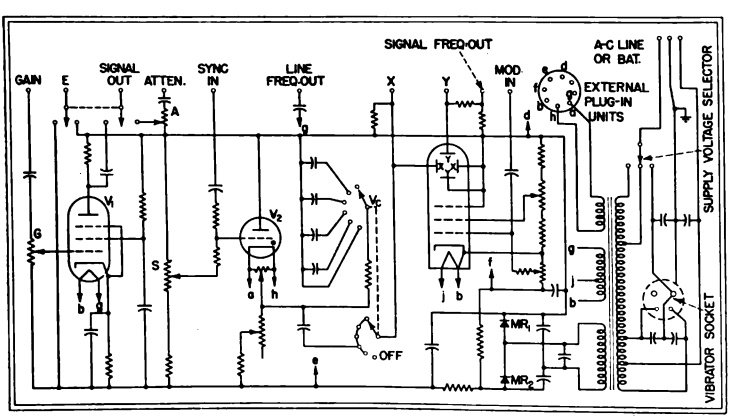


Fig. 1—Complete circuit of the miniature oscilloscope. Provision is made for operation from a 230-v, 50-cycle line, 180-v, 500-volt line, or a 12-v battery

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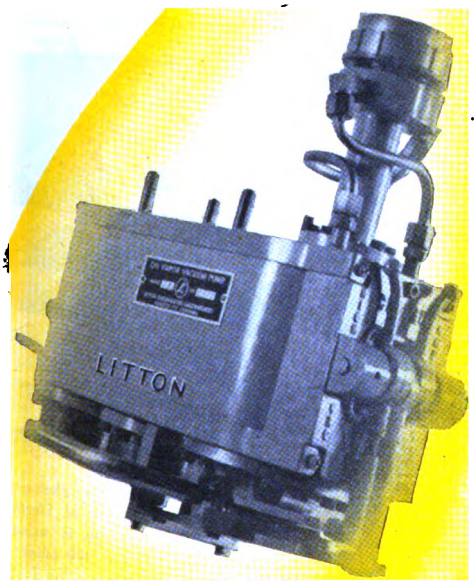

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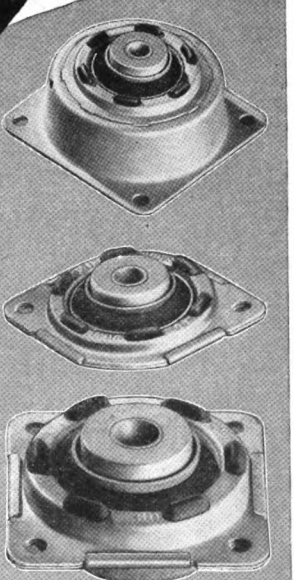

Delicate instruments such as those used on planes, radios and electronics are subject to excessive shock, jolts and vibration in their line of every day duty and need protection in order to operate efficiently for any length of time. • Harris Mounts are widely used because they cradle, cushion and protect these instruments by absorbing up to 90 percent of this jolting, jarring and excessive vibration. Harris Mounts are extremely light in weight yet are rugged and will render unusually long and efficient service. • They are made in accordance with the Army-Navy standards to suit any combination of weight, frequency, deflection or operating condition and come in both cup and plate form. • If you have a problem, just drop us a line, our engineers, specialists in the field of engineered vibration control will gladly work with your engineers. Our free bulletin series 1022 on Harris Mounts will be gladly mailed upon request. Send for it today.

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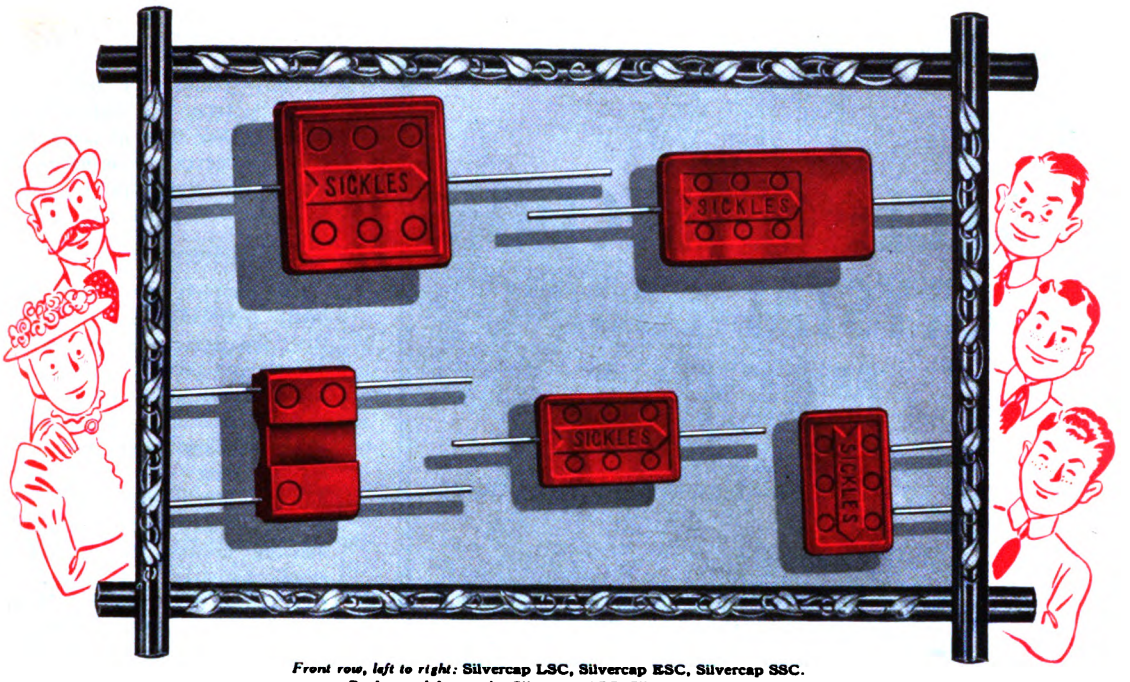

Front row, left to right: Silvercap LSC, Silvercap ESC, Silvercap SSC.
Back row, left to right: Silvercap ASC, Silvercap BSC.

The Sickles "SILVERCAP" Family

SEPTEMBER, 1945

Way, way back in the early 30's, Sickles presented the first *Silvercap* Condenser, a vast improvement over its ordinary mica predecessor. The *Silvercap* used silver conducting surfaces bonded to their mica dielectric. Thus, motion between plate and dielectric was eliminated and a highly stable, uniform unit was the result.

Years of research and development followed this first model until today, the *Silvercap* family can count five highly improved members. All are made with the highest quality mica and molded with the best grade of red phenolic. These, and careful attention to details, combine to produce a unit that is unexcelled for a dependable, permanent, accurate block of fixed capacity.

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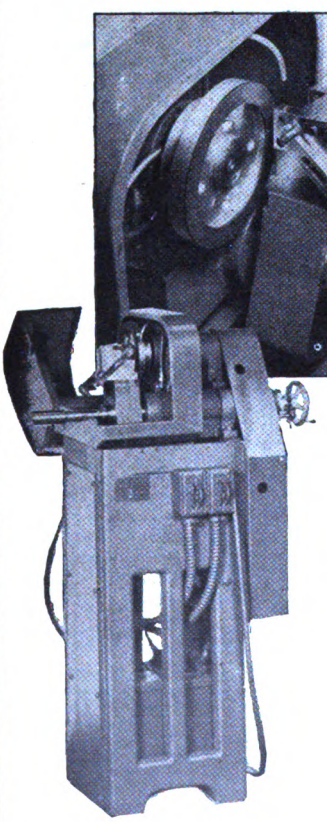

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at any point and thereby the azimuth from the station at any point, rather than at points lying only on certain specific courses where the signal ratio is unity, as in current practice.

Antenna System

The complete transmitting equipment comprises the transmitter, the subcarrier modulator, the goniometer, and the antenna. Five radiating elements are located at the corners and at the center of the customary square employed in d-f systems. Opposite pairs of antennas are operated 180 degrees out of phase and the electrical spacing between the elements is small compared to the wavelength so that a figure eight field pattern results. This field pattern is caused to rotate by means of a capacitance goniometer which is driven by a synchronous motor at 3600 rpm.

The rotating goniometer acts as a balanced modulator. It eliminates the carrier frequency, and supplies sideband energy at carrier frequency plus and minus sixty cycles to the two antenna pairs. Since the entire field is in effect rotated once for each rotation of the goniometer, each direction in space will have a certain phase of the rotational frequency associated with it and this phase will change degree for degree with a change in azimuth relative to the station. If then we have a signal supplying a voltage of reference phase which is independent of azimuth, we may determine azimuth from the station by comparing the phase of the two received signals.

Reference Modulation

The reference signal is provided by means of sixty-cycle modulation applied to a 10-kc subcarrier which in turn modulates the carrier radiated from the center antenna. The 60-cycle modulating voltage for the reference phase signal is derived from a small alternator driven on the shaft of the motor which rotates the goniometer, so that a constant phase relationship is always maintained between the two signals. With one diagonal antenna pair accurately aligned in the local meridian, and the other

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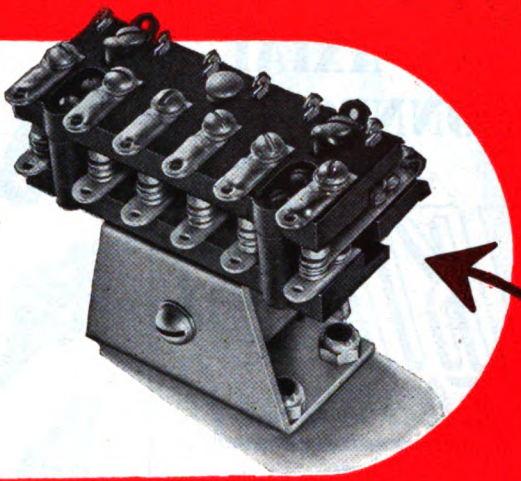
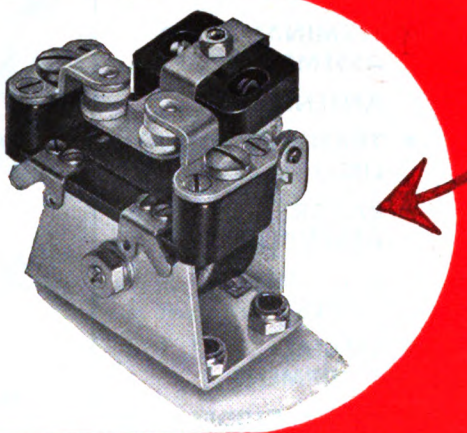


TYPE BN

The Allied 6-pole, double-throw BN type embodies many new improvements for heavy duty 6-pole switching . . . permits individual adjustment of contacts. Molded Bakelite is used throughout the relay. Contacts are rated at 10 Amperes. As in all Allied relays, the BN is designed for compactness and minimum weight. May be furnished normally open or normally closed or double-throw. Available in AC or DC. Weighs 11 oz. Write for complete operating characteristics, etc.

Height: 2 9/16" Length: 3" Width: 1 23/32"



TYPE CN

The CN relay is the result of advanced engineering technique and succeeds Allied's successful AN type . . . a power relay expressly designed for breaking heavy current. Contact rating is 50 Amperes at 24 Volts DC with silver contacts; with alloy contacts the contact rating is 75 Amperes at 24 Volts DC. *(The latter arrangement with the alloy contacts is known as the CNS type.)* The contact arrangement is single pole, single throw, double break, normally open or normally closed. The new design incorporates molded Bakelite insulation, greater electrical clearance and over-all improved mechanical structure. Available in AC or DC. Complete data on request.

Height: 2½" Length: 2¼" Width: 2"

The two relays described above are typical examples of the many new types of relays Allied is constantly designing for its customers' widely diversified requirements. Allied's engineering staff continually works to improve relay designs and to develop new magnetic control devices for present and future manufacturers whose products require electrical control. The highly practical accumulated knowledge of these men is at your command. Send us your control problems!

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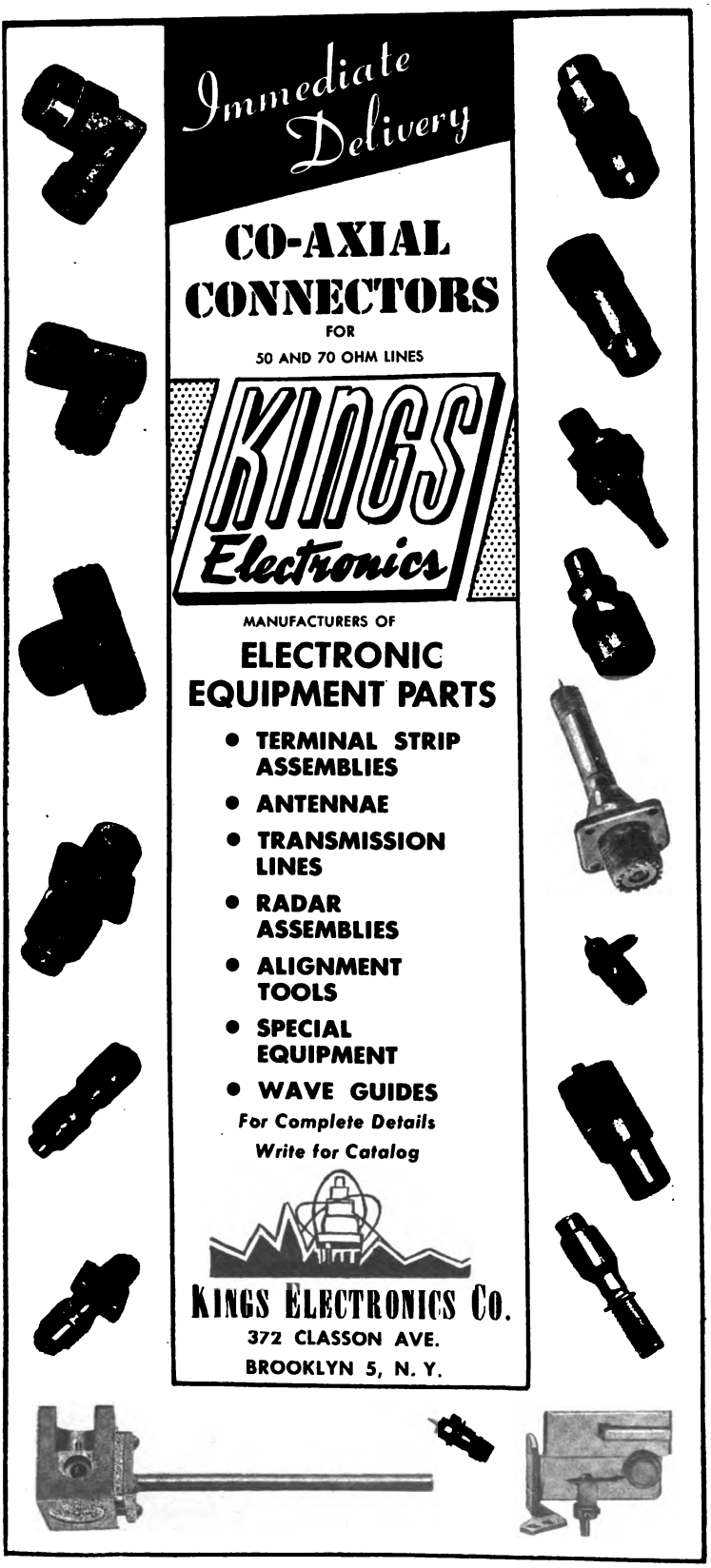

pair at an exact right angle, the practice is to have the voltages from the two signals in phase in the true north direction with clockwise rotation of the pattern.

The total signal consists of a carrier which is amplitude-modulated so that the phase of the modulation is directly equal to the azimuth angle. The carrier is further modulated by the reference phase subcarriers. These may be separated in such a way as to leave the above result unaffected.

Receiving Equipment

The receiver is a conventional vhf superheterodyne up to and including the second detector. At this point, a filter, separates the 10-kc subcarrier, and another detector separates the reference phase voltage from the modulated subcarrier. The reference voltage is then amplified, split in phase, and applied to the two primary windings of a magnetic phase shifter. The output of the phase shifter feeds a wattmeter circuit together with a voltage derived from the variable phase signal. The indicating element of the wattmeter circuit is a standard zero-center meter which is used in aircraft as the course indicator.

A circular scale on the phase shifter is graduated in degrees from zero to 860 and an indicating pointer is attached to the rotor shaft. After the station is tuned in, the phase shifter is rotated manually until the pointer is centered. The azimuth from the station is then read from the scale on the phase shifter.

Indicators

A course along the azimuth line may then be flown by reference to the zero-center meter, which will indicate deviations from the course by deflections in the corresponding directions. When courses are flown along lines which do not pass through the station, a continuous check on azimuth from the station may be maintained by keeping the meter centered by manual adjustment of the phase shifter.

The azimuth may be indicated automatically and continuously by a means similar to that used with automatic direction finders. Such

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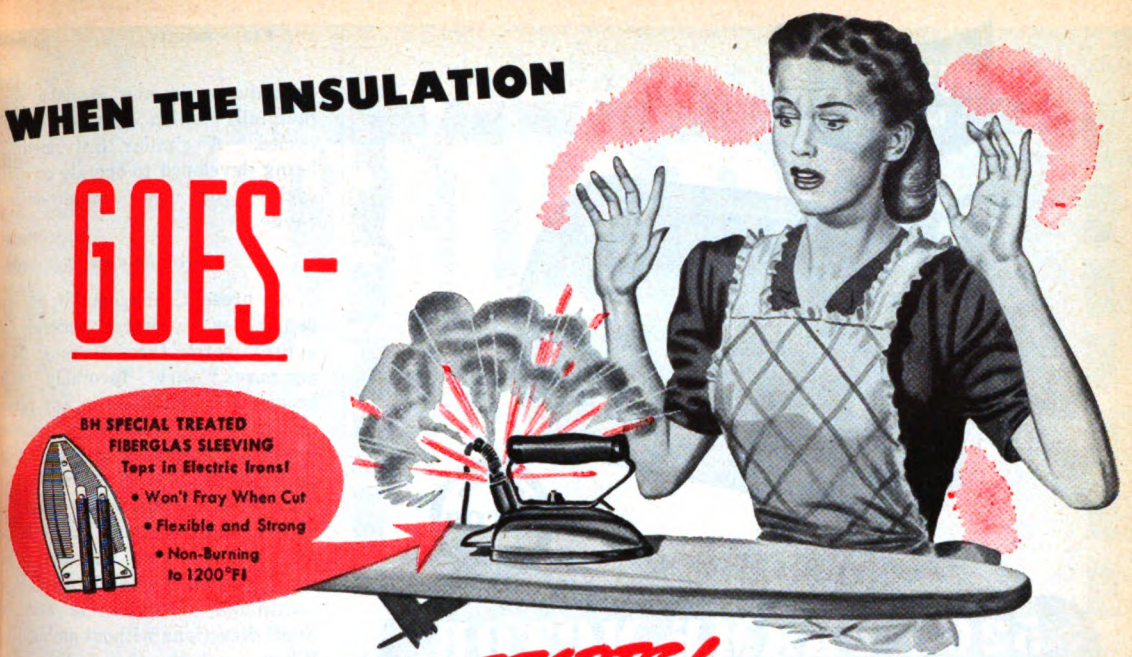
WHEN THE INSULATION GOES—



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WHAT does it mean to *you* when Mrs. Smith's electric iron goes *phht?* If electrical insulation is a part of *your* product, whether it's appliance, radio or electrical equipment, you, like the iron manufacturer, run this *risk*. The risk of insulation failure—of inconveniencing customers, jeopardizing good will, and possibly losing sales.

Since your product's performance may depend on a few cents worth of insulation, be sure to use the best. Assure trouble-free service with BH Fiberglas Sleeving, the *original* non-fraying, non-stiffening, non-burning Fiberglas sleeving. An exclusive BH process combines *permanent* freedom from hardening, cracking or rotting with the many advantages of Fiberglas — including high dielectric and tensile strength, resistance to moisture, oil, grease and most chemicals.

Severest wartime uses prove beyond question the superior qualities of all three BH Fiberglas Sleevings in electrical applications for home and industry. One of them may fit your needs to a "T"—*plus!* Write for free BH samples today and put them to the toughest tests your product can dish out!

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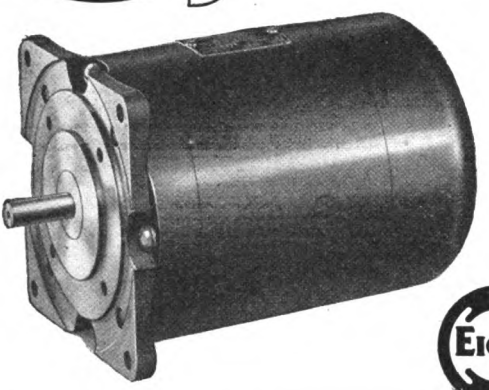

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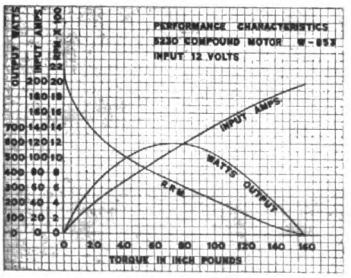

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Low space factor
Ball bearing equipped
Optional shaft details
Rugged construction

5200 FRAME MOTORS		5220 Shunt	5230 Compound
Output, Con. (H.P.)		1/4	1/4
Torque at 3900 RPM	(in. lbs.)	4.5	
Torque at 1625 RPM	(in. lbs.)		10
Lock Torque	(in. lbs.)	45	160
Volts input	(min.)	6	6
Volts input	(max.)	110	110
Diameter		5 1/4"	5 1/4"
Length less shaft		8"	9"
Shaft Dia.	(max.)	1/2"	1/2"
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an indicator is now available commercially which operates on 400 cycles. A similar instrument is being developed to operate on sixty cycles for the omnidirectional range.

Advantages

At present, the omnidirectional range has an overall accuracy of approximately three degrees. This compares very favorably with accuracies obtainable in any range or d-f system suitable for use over moderate distances and providing at least on and off course indications over the entire 360 degrees.

The omnidirectional range is an improvement over any device so far proposed in that it provides a continuous indication of azimuth in all directions without ambiguity. When used together with a distance indicator, a continuous indication of position is obtained which completely solves the navigation problem.

• • •

Use of Shunt Diode for Supplying Bias Voltage

IT IS AN UNFORTUNATE fact that radio men in general do not recognize the full potentialities of the shunt diode. In the two bias supplies to be described, shunt diodes are used for rectification with attendant advantages.

The conventional bias supply for amplifier use is shown in Fig. 1. In this circuit, a diode (usually a

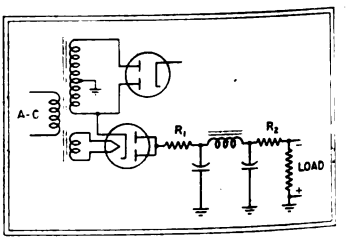

Fig. 1—Conventional method of obtaining bias from the high-voltage winding of the power transformer

6X5) is reversed and used as a half-wave rectifier for negative output. Because the heater-cathode rating will usually be exceeded, it is necessary to use a separate heater winding which frequently

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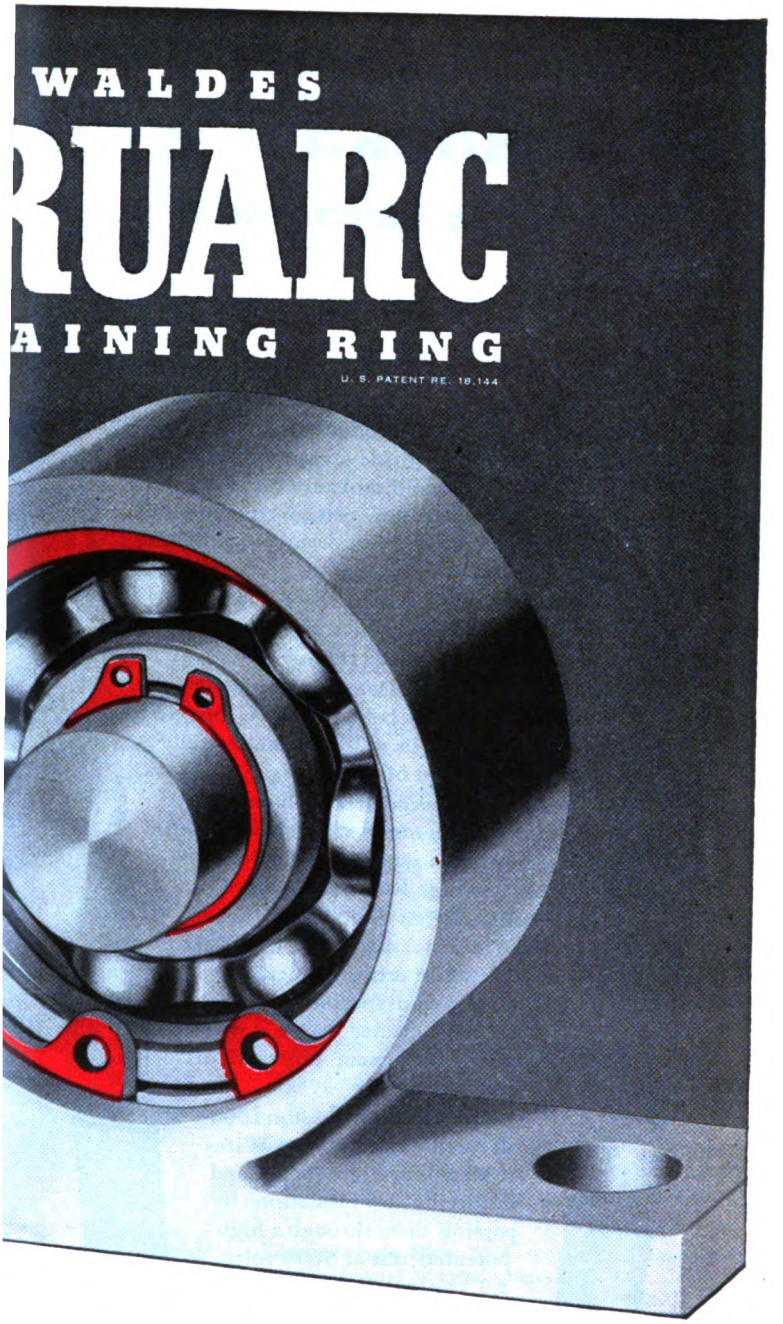

Waldes Truarc expands or contracts without distortion and without permanent set, fitting tight all around the groove. It offers important advantages over shoulders, nuts, collars, etc., for all thrust-load fixings in shaft and housing applications. It saves space, weight, assembly time and machining costs. Waldes Truarc presents a significant advance in retaining rings, well worth your thorough investigation. We will gladly furnish samples and full data for tests, upon request.

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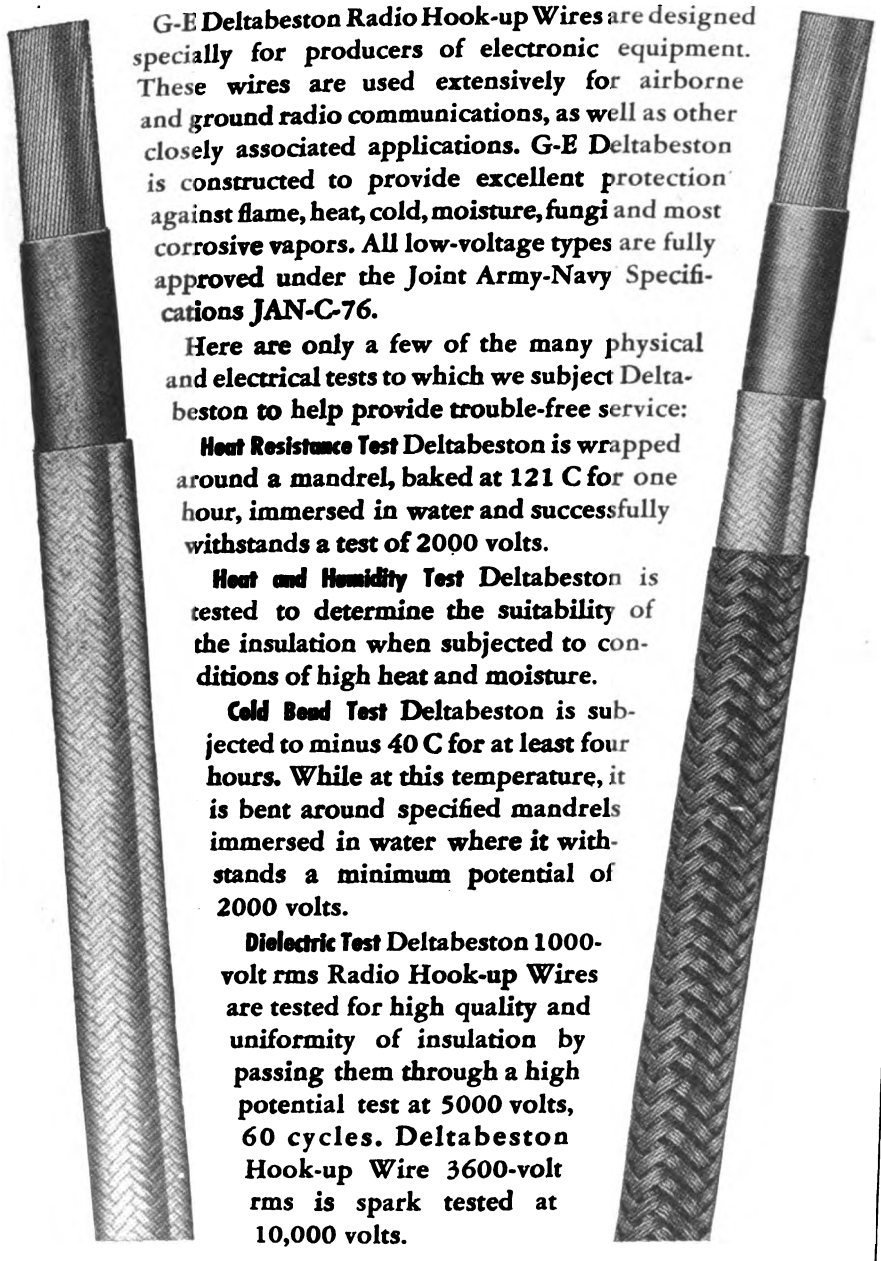
DELTABESTON
RADIO HOOK-UP WIRES
Designed For Electronic Devices



G-E Deltabeston Radio Hook-up Wires are designed specially for producers of electronic equipment. These wires are used extensively for airborne and ground radio communications, as well as other closely associated applications. G-E Deltabeston is constructed to provide excellent protection against flame, heat, cold, moisture, fungi and most corrosive vapors. All low-voltage types are fully approved under the Joint Army-Navy Specifications JAN-C-76.

Here are only a few of the many physical and electrical tests to which we subject Deltabeston to help provide trouble-free service:

Heat Resistance Test Deltabeston is wrapped around a mandrel, baked at 121 C for one hour, immersed in water and successfully withstands a test of 2000 volts.

Heat and Humidity Test Deltabeston is tested to determine the suitability of the insulation when subjected to conditions of high heat and moisture.

Cold Bend Test Deltabeston is subjected to minus 40 C for at least four hours. While at this temperature, it is bent around specified mandrels immersed in water where it withstands a minimum potential of 2000 volts.

Dielectric Test Deltabeston 1000-volt rms Radio Hook-up Wires are tested for high quality and uniformity of insulation by passing them through a high potential test at 5000 volts, 60 cycles. Deltabeston Hook-up Wire 3600-volt rms is spark tested at 10,000 volts.

For complete information, write to Section Y956-119, Appliance and Merchandise Department, General Electric Co., Bridgeport, Conn. All Deltabeston Wires and Cables are distributed nationally by Graybar Electric Co., General Electric Supply Corp. and other G-E Merchandise Distributors.

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across the input f
often too high, it
by R_1. If we want
volts or less of bias
we must have an
ping resistor R_2. T
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The circuit of
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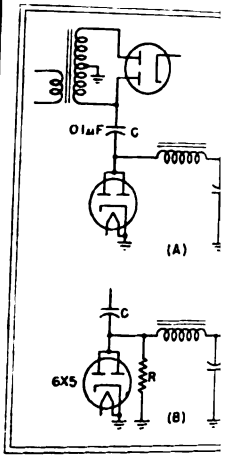

Fig. 2—At *A* is a circ
bias with a shunt dio
acts in conjunction wi
sistor to form a voltage
only one bias voltage
circuit shown at B i

heater supply. The
directly across the
capacitor and the dro
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provide even better filte

The circuit of Fig. 2

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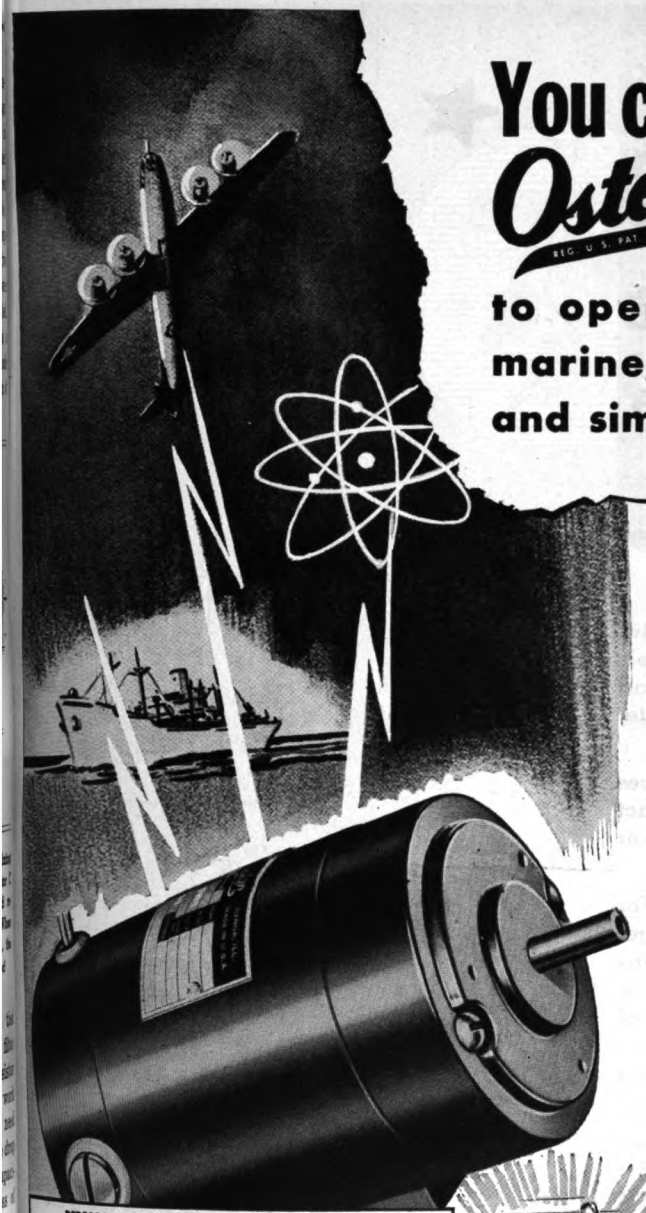


You can rely on this Oster Blower Motor

REG. U.S. PAT. OFF.

to operate dependably in marine, aircraft, electronic, and similar applications . . .

In planning your post-war product, it is well to remember the design and operating advantages of this Oster blower motor. Although it has been especially designed for use in the marine, aircraft, and electronic fields, it may have qualities that fit your particular product. Check these features:

Housing: Die cast, zinc field housing and aluminum end brackets. Totally enclosed.

Finish: Black baked enamel.

Weight: 5 lbs.

Bearings: Single shielded ball bearings lubricated with a grease suitable for any specific application. Bearing housings fitted with steel inserts.

Windings and Insulation: Field coils and armature wound with a select grade of insulated copper wire and impregnated with a high quality heat and moisture resisting insulating varnish.

Mounting: Available with either base mounting or machined pads.

Brushes: Metal graphite or electro-graphite brushes of ample size to assure unusually long brush life. Phosphor bronze or beryllium copper brush springs.

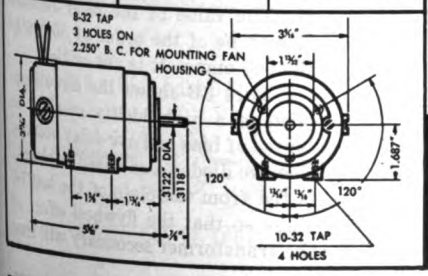
Temperature Rise: 55°C. maximum frame temperature rise at rated output.

Modification: Motors can be furnished with special shaft extensions, mounting arrangements, finishes, leads, etc.

Let us help you fit this and other Oster Motors to your requirements.

Buy **WAR BONDS**

PERFORMANCE WITH #3 L-R TURBO TYPE BLOWER		
Type	F-9A-3	F-9-4S
Voltage	115 A.C. 60 CYC.	27 D.C.
Amps. Input	2.7	7
R.P.M.	6000	6000
Rotation	Clockwise Drive End	Clockwise Drive End
Starting Torque in % of F. L. Torque	200	300 — 400



You can recommend Oster Motors with full assurance that they will live up to the world-wide reputation of pre-war Oster appliances, Oster-powered.

M-24

John Oster Manufacturing Co.

DEPARTMENT L-24 • RACINE, WISCONSIN

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BIMETAL CONTROLS
—an Expanding Field of Peace-time Usefulness

The makers of temperature responsive controls—now playing an indispensable part in winning the war—will take an even greater part in building a better postwar world.

The demands of Industry for devices to control processes, to assure exact temperatures, to protect machines or motors against heat or stress—

The demands of Transportation for proper temperatures in both passenger cars and in freight-cars carrying perishable goods, as well as for giving the "green light" to over 500,000 miles of rails, 24 hours a day—

The similar demands of aviation, and even of our private automobiles, in which there are now more than 16 applications of bimetal control; and the insistent demands of our homes for more and better automatic home appliances—

From all these sources the builder of thermostatic controls may confidently expect a flood of orders when peace comes again. And in addition, he may rely upon many new developments in which Chace Thermostatic Bimetals can profitably be used. Over 20 years of Chace experience will be at his command.

W. M. CHACE CO.
Manufacturers of
Thermostatic Bimetals and Special Alloys
1630 BEARD AVE • DETROIT 9, MICH.

values shown, del
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2A3's. The ripple
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Practical

An adaptation o
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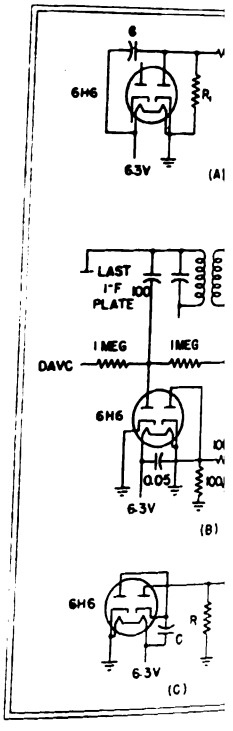

Fig. 3—Bias voltage for r
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Figure 3B shows th
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stage so that the flywh
the transformer second

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Transformer Specialists . . .

Thordarson's tradition of quality provides the underlying reason for its past half-century of progressive leadership in the specialized manufacture of dependable transformers, components and other electronic devices. This same tradition, upheld through every phase of *Thordarson* design, engineering and manufacturing is your guarantee of the finest transformers for requirements of Tomorrow . . . and years to come. With confidence . . . gained by this ability to produce quality merchandise and coupled with novel sales policies . . . *Thordarson* looks forward to supplying the expanding demands of the radio and electronic industries.

500 WEST HURON ST., CHICAGO, ILL.

ORIGINATORS OF TRUE-FIDELITY AMPLIFIERS

THORDARSON

ELECTRIC MANUFACTURING DIVISION

MAGUIRE INDUSTRIES, INCORPO

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NEW VACUUM TUBE FREQUENCY METER . . .

Model 39-VTF, Series A, showing simplicity and portability.

. . . FOR FREQUENCIES IN 400 800 1200 1600 2400 3600 CYCLE BANDS

MODEL 39-VTF, Series A, a new development of J-B-T engineers, measures frequencies in six specific bands with accuracy of ± 0.25% of the frequency being measured, and with sufficient amplitude to be easily read.

Vacuum tube multivibrator circuits divide the incoming frequency by 1, 2, 3, 4, 6 or 9, depending on the position of the multiplier switch, and show the result on the time-tested, standard 400 cycle meter.

Regular line current is used for power supply, permitting an input sensitivity of 500,000 ohms. Response is not affected by irregular wave form, nor by harmonic content of unknown frequencies of less than 10% or 15% . . . and input control permits use from 100 to 350 volts.

The result is an instrument of high accuracy and high stability with permanent calibration . . . especially useful for checking audio oscillators, frequency converters, radar equipment, and for standardizing less accurate frequency measuring units.

Check These Points

- **EXTREME ACCURACY** ... within ± 0.25% of frequency being measured.
- **PERMANENT ACCURACY** . . . no further calibration or standardization required at any time.
- **STABILITY** ... no temperature drift after initial 30 second warm-up.
- **BURN-OUT PROOF** . . . no protection needed against accidental above-range frequencies.
- **SENSITIVITY** . . . 500,000 ohms.
- **SIMPLICITY** ... uses standard tubes.
- **POSITIVE SWITCHING** ... built-in switch is J-B-T's own rugged, coin-silver plated instrument switch, as supplied for high quality testers.

New Booklet . . . just off press, illustrates other types of J-B-T Vibrating Reed Frequency Meters. Ask for Bulletin VF-43-1C.

J-B-T

Manufactured under J-B-T and/or Triplett Patents and Patents Pending

J-B-T INSTRUMENTS, INC.

431 CHAPEL STREET • NEW HAVEN 8, CONN.

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Figure 3C sh
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Popular Radar Made in Ameri

THE TUBE THAT abroad in radar receiving types cc as the VR-91. B formance at uhf, 284 types of Briti

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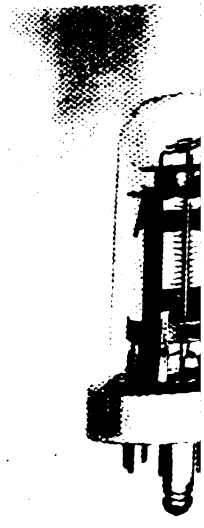

Receiving tube type VR types of British rad

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Seventeen major made in the British ing grids, micas, gett mount support, shield of testing. The dia

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CATHODE RAY TUBES THAT MEET EXACTING SPECIFICATIONS

NORTH AMERICAN PHILIPS is one of the few manufacturers of electronic tubes endowed with the skill and experience required for the mass production of the 5JP1 and similar cathode ray tubes.

The deflection-plate terminals of these tubes are brought out at the neck of the glass envelope to provide higher insulation and lower lead capacitance at very high frequencies.

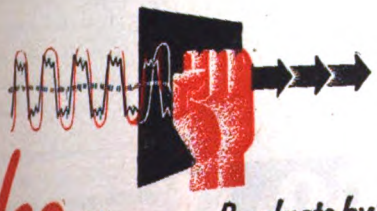
In the manufacturing procedure the tubes are cracked at the neck, the deflection-plate leads bent out, and the envelope sections rejoined on a glass-sealing lathe, as illustrated. During this operation the tubes are maintained at a high temperature to prevent the formation of water vapor on the fluorescent screens.

The ability to produce, in volume, NORELCO cathode ray tubes that meet exacting specifications is the result of experience gained by an organization with a background of over half a century of research and development in the electrical field.

The facilities which North American Philips has applied to the manufacture of electronic tubes in wartime will be immediately available for the post-war production of cathode ray tubes for direct viewing and projection television.

Write today for interesting booklet on "How and Why Cathode-Ray Tubes Work."

When in New York, be sure to visit our Industrial Electronics Showroom.



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Electronic Products by

OTHER PRODUCTS: Quartz Oscillator Plates; Searchray (Industrial X-ray) Apparatus, X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Tungsten and Molybdenum Products; Fine Wire; Diamond Dies.

NORTH AMERICAN PHILIPS COMPANY, INC.

Dept. C-9 100 East 42nd Street, New York 17, N. Y.

Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Div.); Lewiston, Me.

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RADIO MEN!

The first time you listen with Murdock Phones, you know that here is clear reception with perfect comfort — and this is why:

1. **MURDOCK "precisioneering" brings the message through naturally—without strain, chatter or distortion.**
2. **MURDOCK'S "solid-built" durable construction protects the fine, sensitive adjustments from shock.**
3. **MURDOCK'S "air-cushioned" phones provide long listening without head discomfort.**
4. **MURDOCK'S ventilation means cool comfort—prevents condensation.**
5. **MURDOCK'S two-way adjustment controls position for smoother performance.**

Murdock's entire factory is now working for Uncle Sam. But as soon as victory is won, Murdock men, machines and materials will resume their peacetime position as a leading manufacturer of radio phones, telephone and electrical specialties for civilian use.

Plan for that peace now. Write today for new catalog.

MANUFACTURERS: We're at your service to help you turn out more Radio Phones and related parts. Our organization has had 40 years' experience. Write us today.

WM. J. MURDOCK CO.
Carter St., Chelsea 50, Mass.

RADAR TUBES

No. 1 grid wire w
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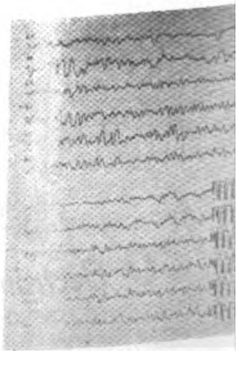

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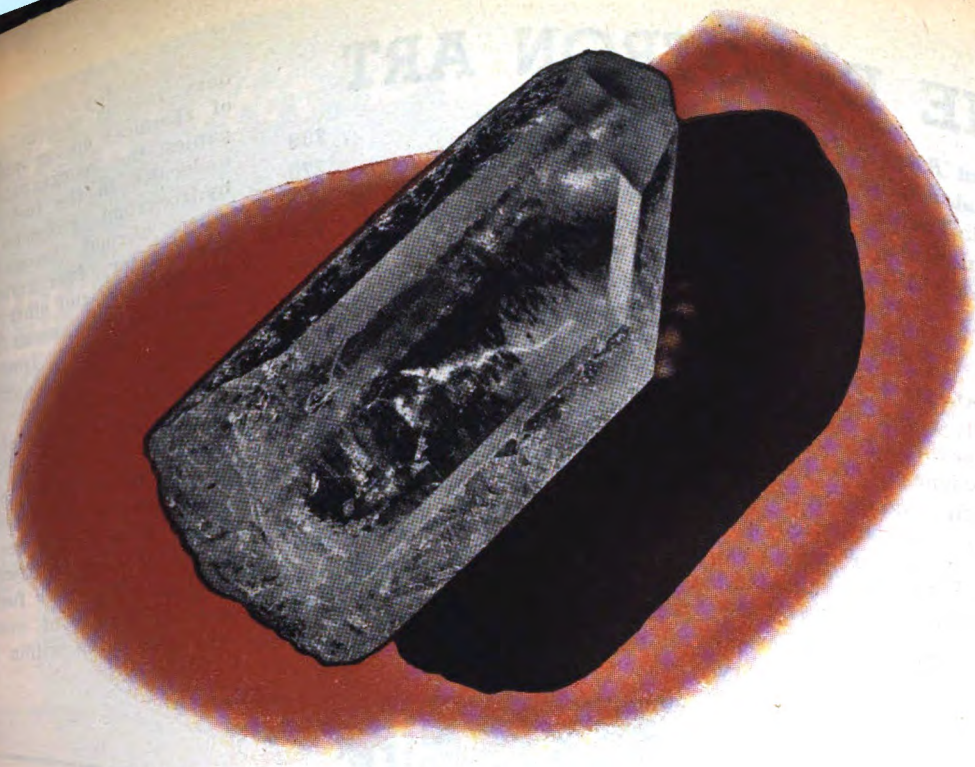

Here all similarity ends...

...om this point on, it's craftsmanship!

...e important respect there is a ...g similarity between the mil... ...of Bliley crystals which we now ...ce and the mere handful of ...m made units that constituted ...nnual production when radio ...still young.

...early days of radio, when ... crystal was painstak... ...and ground by hand, a ... was born. It was a tradi... ...manship that has grown ... years—a tradition that ...ley engineers have successfully ...slated into the more intricate ...niques of volume production.

Etched crystals are an outstanding discovery and development of Bliley research engineers. This technique, by means of which crystals are finished to frequency by acid action rather than abrasive action, was an established part of Bliley production long before Pearl Harbor. It has since proven to be an essential element in the manufacture of crystals that have the dependable characteristics necessary for military communication in global warfare.

We have been called upon to solve some knotty problems. But that is nothing new at Bliley. It has been our habit to parallel new developments in radio with the right crystal for each application.

Things will be different soon. Peacetime projects will again come first. **But our engineers and craftsmen will be ready, as always, with the right answer to your requirements. Don't fail to include Bliley crystals in the component specifications for your peacetime equipment.**

A new star has been added

Bliley CRYSTALS

Do more than before...:

buy **extra** War Bonds

...LEY ELECTRIC COMPANY UNION STATION BUILDING · ERIE, PEN

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THE ELECTRON ART

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Decibel Calculator 294
Generation of Millimeter Wavelengths 298

Facts About Atomic Power*

THE PRACTICAL MAN in engineering is usually somewhat skeptical of the endeavors of his brothers in the pure sciences. To him the problem of designing and maintaining a modern communication system, for example, is far more vital than the knowledge that mass and energy are different aspects of the same thing. But the practical engineer who has read the history of technology knows that the theoretical postulates of science may turn out to be of the greatest practical importance. Knowledge pursued for its own sake has time and again declared a big dividend.

An excellent example of such corporate finance in the scientific world is now before the public eye, so much so in fact that the story appeared on the front page of the *New York Times*—at a time when the ordinary affairs of men have been consistently relegated to the inside pages. The story is the isolation of the isotope of uranium whose atomic weight is 235 and whose symbol is U^{235}.

U^{235} appears to be the first true atomic fuel discovered, and although its practical importance in the affairs of men at present is precisely nil, its potentialities are sufficient to fire the imagination of anyone whose background permits them to understand the facts in the case. The readers of *Electronics* fall in this class, hence your editors have sought out the factual references in the matter, and have attempted to separate the actualities from the guesswork and the wishful thinking.

What Is an Atomic Fuel?

It need hardly be said that modern technology depends upon sources of power, and that sources of power depend on fuel, either directly or indirectly. The fuels thus far available to industry have been in the *chemical* class. Coal and oil, for example, are useful to us because they are unstable chemical substances which can be ignited and which thereafter will continue to furnish heat until they are consumed, provided they are kept in a suitable burner or furnace. The burning process in ordinary fuel is essentially a release of chemical energy which accompanies the reorganization of the molecules in the fuel. Thus the hydrocarbon molecules of coal, when burned, become separated into water, free carbon, carbon dioxide, ash and other combustion products. The energy freed in the process results from the reshuffling of the atoms and the outer electrons of the atoms concerned. The nucleus of each atom, however, remains unchanged.

For some time the physicists have known that an entirely different kind of fuel lies within the range of scientific discovery. That fuel is the *atomic* fuel, in which great amounts of energy can be liberated from within the nucleus

The "match" for atomic fuel. Neutrons generated in this huge cyclotron at Columbia University were used to irradiate the sample of U^{235} isolated at the University of Minnesota. The neutrons, slowed down by passage through paraffin, induce instability in the uranium atoms, causing them to explode with tremendous energy. Thereafter the uranium isotope, if available in sufficiently pure form, will maintain its own "combustion"

* Reprinted from ELECTRONICS, July 1940, p. 12.

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Eastern Air Devices Announces

another new 400 cycle blower unit

MODEL J81 AXIAL FLOW BLOWER

4"

AIR DELIVERY (FREE AIR)

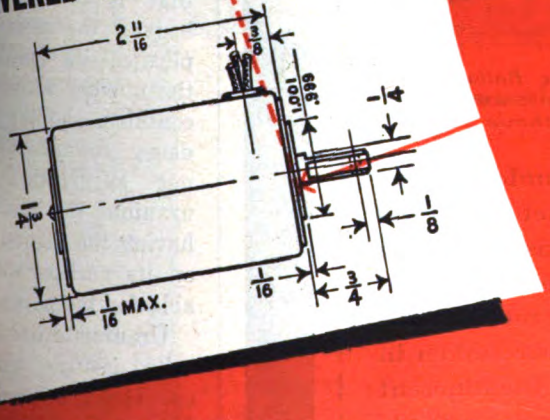
375 C.F.M. (NEMA CODE)

140 C.F.M. (NAFM CODE)

400 cycles • 115 volts • 6500 RPM 50 watts input • 1.0 mfd. condenser required • starting torque 2.25 oz. in • 80% power factor • weight of unit 16 oz. Fan: 4 blade propeller type, 4-inch diameter.

We invite inquiry!

POWERED BY MOTOR J33D



SINGLE PHASE

CAPACITOR INDUCTION MOTOR

1/50 H.P. • 400 cycles • 115 volts • 0.02 rated H.P. 6500 R.P.M. • Continuous duty as axial fan drive. Intermittent duty for general use • starting torque 2.25 oz. in • 80% power factor • 1.0 mfd. capacitor required • weight of unit 15 oz.

EAD

EASTERN AIR DEVICES, INC.

585 Dean Street • Brooklyn 17, N. Y.

An Affiliate of The Fred Goat Co., Inc., Est. 1893

MANUFACTURERS OF CONTROL DEVICES AND COMPONENTS FOR ELECTRICAL, ELECTRONIC AND MECHANICAL APPLICATIONS

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LECTRONIC AC VOLTMETER

with Logarithmic Scale

Percentage Accuracy of reading is uniform over entire scale!

MODEL 300
ELECTRONIC
VOLTMETER

ACCESSORIES

DEL 220 DECADE AMPLIFIER
MODEL 402 MULTIPLIER

Since its development in 1935 the Ballantine Electronic AC Voltmeter is the only instrument of its kind with a Simplified Logarithmic Scale.

The important feature of logarithmic scale indication in the Ballantine Voltmeter provides the same degree of accuracy at 1 as at 10. Also the simplicity of this scale reduces errors in visual observation, common with most multi-range instruments. Finally, the care taken in overall calibration combined with the inherent stability of the circuits used permits reliable readings within the 2% specified tolerance over the complete range of operation.

Write for descriptive technical Bulletin 8

BALLANTINE LABORATORIES, INC

BOONTON, NEW JERSEY, U. S. A.

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From Metal Fabrication to Finished Unit . . .

IT'S WILCOX ALL THE WAY

Not merely an assembler . . . the Wilcox plant is equipped and staffed with skilled craftsmen to make most all the parts of radio control, transmitting and receiving equipment, from microphone to antenna. Every product is "Wilcox all the way" —from the engineer's blue print and precision fabrication of sheet metal to the final assembled units. Where the name Wilcox appears, dependable quality is assured . . . in radio communications for ground stations and aircraft, police, public address systems and associate equipment.

Remote Receiver Bay—using Single Frequency Crystal Controlled Receivers. Wilcox Type F and Type CW unit; another example of the completeness and versatility of the line.

WILCOX ELECTRIC COMPANY, INC.

Manufacturers of Radio Equipment

Fourteenth and Chestnut — Kansas City 1, Missouri

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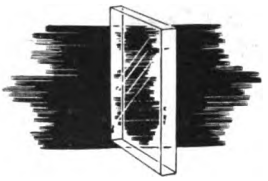

A NEW KIND OF RADIO PUSH-BUTTON

The prewar push-button station selector was a great improvement over dial-tuning of radio. But jabbing forefingers soon jolted it off the station frequency.

The public wants that cured.

Crystal-tuning will cure it.

We have developed a circuit, using four crystals, easily interchanged, so that the major local stations can be tuned accurately, exactly on frequency —and as long as the set itself keeps in working order. The crystals cannot change frequency. They cannot go off. Critical war use of Pan-El Control Crystals has demonstrated this, fully.

We are ready to discuss prices, and to produce in quantities, on any schedule you may require, to any specifications you may establish, however difficult. Our engineers will gladly collaborate with yours on any electronic use of control crystals.

ARMY E NAVY

PAN-ELectronics LABoratories, Inc.

500 Spring St., N. W. Atlanta, Georgia

Pan-El QUANTITY PRODUCERS OF STANDARD AND SPECIAL Control Crystals

low energy, corresponding to an electric potential of roughly 1/40 of a volt. Moreover, when the U^{235} nucleus flies apart, from to 2 to 3 neutrons are generated in the process. These neutrons may go off in turn to "set off" and cause the disruption of other nearby U^{235} nuclei. Thus the conditions for a "chain reaction" are available, and the atomic combustion may be made self-supporting. But the chain reaction cannot occur if the atoms of U^{235} are diluted by stable atoms of uranium such as U^{238}, any more than pulverised coal can be made to burn if it is mixed with a high percentage of sand or some other non-combustible material. Hence the need to obtain U^{235} in pure, or nearly pure, form.

In natural uranium, the two principal constituents are U^{238} and U^{235}, which occur in the ratio to 139 U^{238} atoms to every U^{235} atom. Thus the active component U^{235} is so heavily diluted by the inactive component that the atomic combustion cannot be self-supporting until the U^{235} is separated from the combination. U^{238} and U^{235} are identical chemically, hence cannot be separated by chemical methods. The only difference on which separation can be accomplished, so far as is now known, is the difference in their masses, and this difference is only 3 parts in 235, or less than two percent. Here, then, is the rub. Can a simple and economical means be found to separate U^{235} from U^{238}? If so, a new fuel is available which has the virtue of being highly concentrated, and which *may* compete with coal or oil on a price basis, *provided* the several economic and technical questions are satisfactorily answered.

A very interesting analysis of the problem has been worked out by Roberts and Kuper.[1] They point out that U^{235} supplies about 200 million electron volts of energy per atom, whereas coal supplies 4 electron volts of energy per atom. The ratio of energy is then 50,000,000-to-1 on an atom basis. By a weight basis, if we compare coal with uranium oxide as raw materials, this ratio must be divided by the relative concentration of U^{235}, 1 in 139, and by 20 to account

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U^{235}, 1 in 139, and if ...

DIAMOND G MULTI-CLAMP

The Clamp of a thousand uses...

Here's a new clamp that meets the needs of many industries . . . a clamp that solves scores of problems quickly and economically!

The new Diamond G MULTI-CLAMP instantly FITS and HOLDS rubber hosing, metal pipe, tubing, cables and other equipment in a vise-like grip. No wrench, no screw-driver, no disassembling necessary. The patented worm-type self-locking screw assures uniform instant adjustment. Each standard MULTI-CLAMP covers a wide range of sizes and adjustments. Continuous "gear-action" solid band prevents leakage or unequal pressure at any point!

The Diamond G MULTI-CLAMP is corrosive-resistant and meets current Army-Navy specifications. It can be used repeatedly and is practically indestructible. Mechanically held and securely welded . . . a double safety feature! For special purposes, various types of inserts, extra wide bands of metal, plastic or rubber are available.

See the MULTI-CLAMP in action . . . for automotive, aviation, railroad, marine, electrical, hydraulic, pneumatic, electronic, household use and general plant applications. Sample on request.

Easy to Install—no disassembling

Double Safety Feature—mechanically held and welded

GEORGE K. GARRETT CO., INC.
1421 CHESTNUT STREET, PHILADELPHIA 2, PA.

DIAMOND G PRODUCTS

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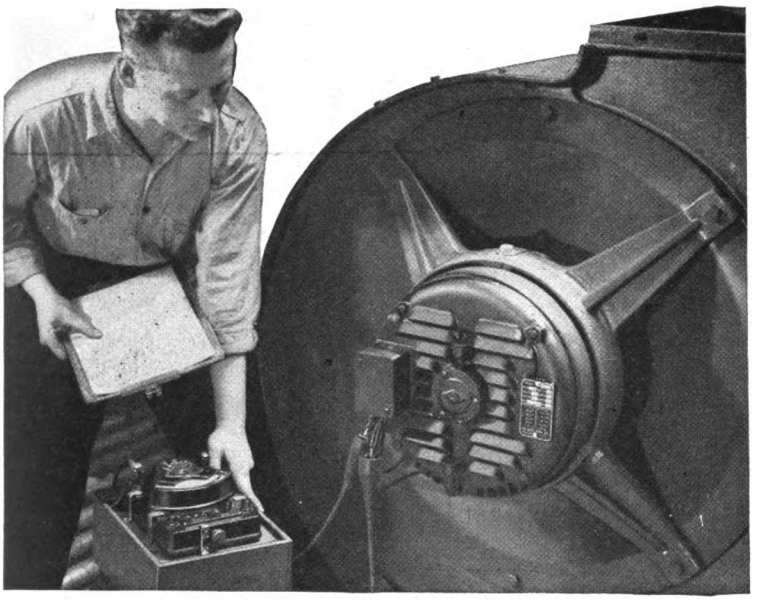
PORTABLE POWER PROBLEMS

THIS MONTH—ILG MOTOR TEMPERATURE TEST



BURGESS INDUSTRIAL BATTERIES power ohmmeters to determine temperature rise in fan motors manufactured by Ilg Electric Ventilating Company. Thousands of industries using test and control equipment rely on Burgess Batteries for dependable service. Your local Burgess distributor can fill your needs from the line designed to meet industrial battery requirements. For full information on the *complete line* of dry batteries write for the name and address of your nearest Burgess distributor now.

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for the difference in the molecular weights. This gives U^{235} an advantage over coal of about 17,000-to-1, on a weight basis, considering the raw materials. What about cost? Uranium oxide costs about $2 per pound or $4000 per ton, whereas coal costs but a few dollars per ton. Thus the cost of energy from coal turns out to be about 8 or 9 times as great as the cost of an equivalent amount of energy from U^{235}, provided that the cost of extracting the U^{235} from the uranium oxide is completely disregarded. No account is taken moreover, of the available supplies of uranium compared with coal, and the trend of the costs of uranium ore which will go up as the supply dwindles, or go down if the supply lasts and the mining methods improve.

The crux of the matter seems to be the cost of extracting U^{235} from U^{238}. If a method can be found which costs less than 1/8th or 1/9th the cost of coal for an equivalent energy production, then U^{235} is in direct competition with coal. Thus far, however, any such extraction method is only a dream. The grim reality is that U^{235} costs much more to extract than it is worth as an energy source. No one knows when an economical process may be found. The whole world is looking for it, but it may never come to light. If so, U^{235} is just a flash in the scientific pan, so far as atomic power is concerned.

There remains however one definite utility in the study of U^{235} which may be realized much more immediately. This possibility lies in the "ash" which remains when U^{235} has been "burned." When the U^{235} nucleus splits apart it forms two new nuclei of comparable weight (roughly 100 and 140 units of atomic weight each). The position of these nuclei in the atomic table approximates that of barium and the nearby elements. Actually, some 20 different types of atoms have been identified as the "combustion products" of U^{235}, and more will no doubt be found. These atoms, moreover, are artificially radioactive. Thus a whole new series of radioactive elements may be produced in quantity and very cheaply. The prospect of

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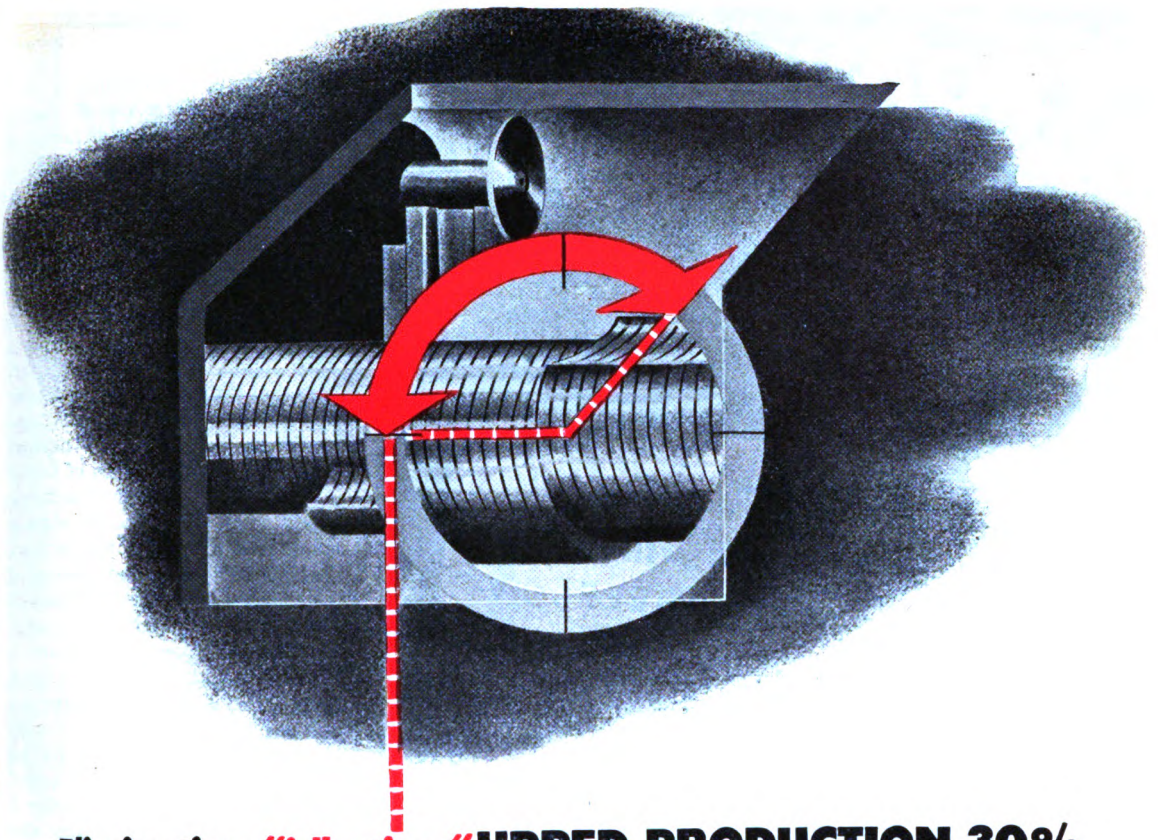

Eliminating "idle time" UPPED PRODUCTION 30%

On cylinder heads for radial aircraft engines, dozens of cooling fins are required. To handle this intricate cutting job automatically, a machine tool manufacturer designed a special fin-milling machine using conventional constant-speed drive to rotate the cylinder head.

But preliminary tests showed that, because of the varying depths of the cuts, production could be increased if an adjustable-speed drive was applied to rotate the workpiece. Due to irregular shape of the workpiece, the milling cutter was usually under light load. At certain points in the cycle, it was out of contact with the metal altogether.

Westinghouse engineers were called in for consultation. Their recommendation: application of the Mot-o-trol — an electronic adjustable-speed drive with accurate load control characteristics. Through its application, rotating speed of the workpiece is greatly increased over the light-load sections—thus eliminating "idle time". Full load is maintained on the cutter regardless of the contour being cut. By these improvements, *production was stepped up as much as 30%.*

This is typical of the modernizing possibilities with electronic equipment in countless industrial tasks. Your nearest Westinghouse office is ready now to supply helpful assistance and information on electronic applications for your industry. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania.

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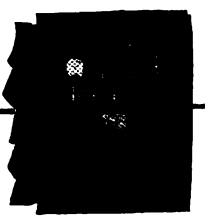

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Famous Radio Feature
Commentator

A Monarch Fact Story

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In London, about 1730, when doctors wanted to test the air for purity, they would send up a piece of beef on the tail of a kite. After 10 minutes the beef would be pulled down, and if it was not spoiled the air was considered healthful. Actually this was NOT a scientific test, because the composition of the upper air is almost surely different from that of the air at ground level.

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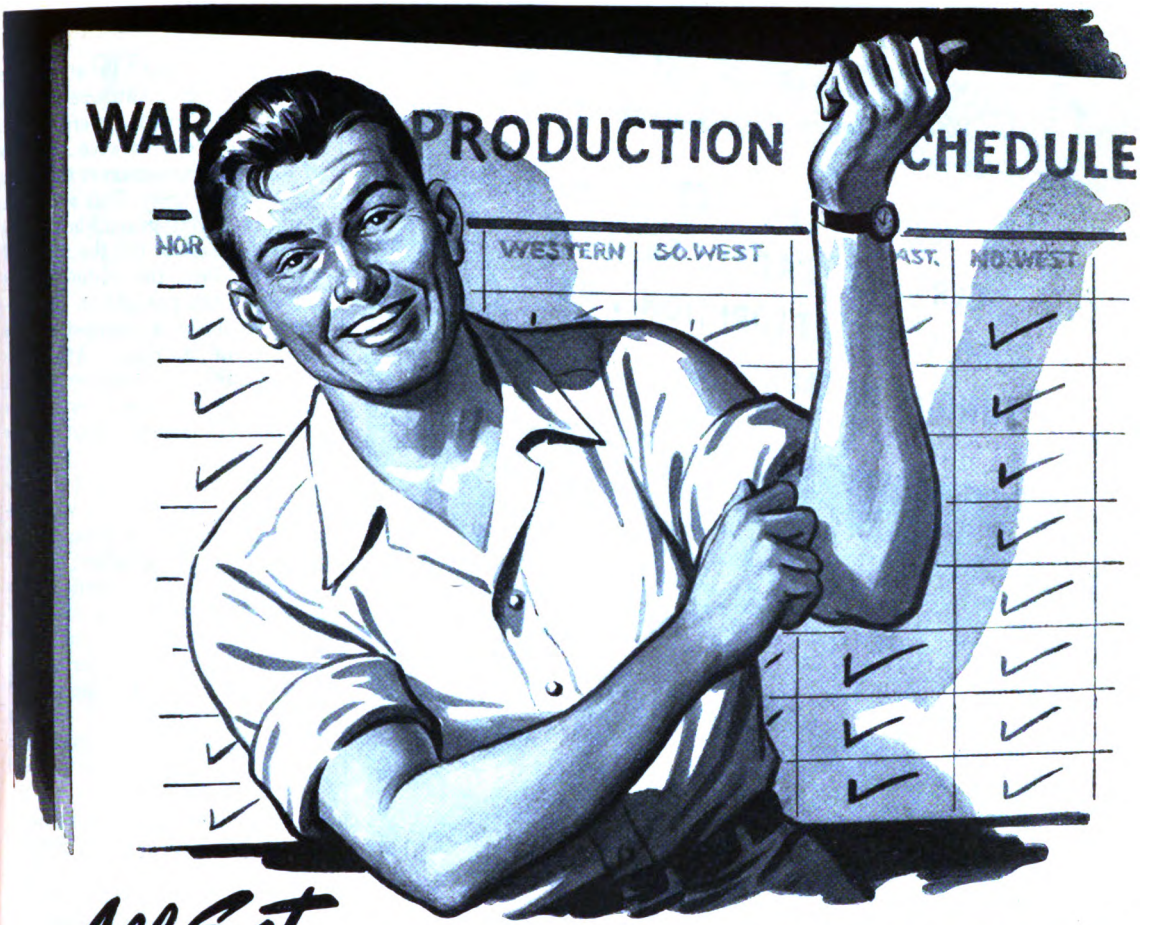

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electrons with the UBr^{+} atoms were drawn through a slit, accelerated to about 1000 volts energy, then caused to move between the poles of a large electromagnet through a semicircular tube. This apparatus, a mass spectrograph, is used to separate atoms on the basis of weight, since the radius of the circular path pursued in the magnetic field by a charged particle depends on its mass. After passing through the semicircular tube, therefore, the heaviest atoms (U^{238}) were deflected least and the lightest (U^{234}) most. Nichrome plates were used to collect the separated streams of ions, which deposited as uranium atoms. In one run of 10 hours duration, 1.7×10^{-7} grams of U^{238} were deposited on one plate, and 1/139th as much of U^{235} (with small contamination of U^{234} also present) on the other. On another run 2.9×10^{-7} grams of U^{238} were deposited. These are truly infinitesimal amounts, and although the yield has since been increased by several hundred times, the isotope can only be said to be isolated, not made available in a practical sense.

The samples of U^{235} and U^{238} were then taken to Columbia University and bombarded with neutrons generated in the cyclotron in the Physics Laboratory by Booth, Dunning, and Grosse. The neutrons used were slowed down by passage through paraffin, since they are generated at too high a velocity by the cyclotron itself. In one run, only one fission (atomic disruption) in 100 minutes was noted with U^{238} and one every 2 minutes was noted with U^{235}. In a second run no fissions were noted within the experimental error with U^{238} and nearly one fission per minute was noted with U^{235}. This was the first experimental evidence reported[2] that U^{235} was in reality the seat of the atomic disruptions. The conclusion was reached that experiments with the possibility of a chain reaction should be confined to U^{235}. This report, in a letter in the *Physical Review*, was the signal for the newspaper reports which brought the matter to the attention of the public.

Physicists at the General Elec-

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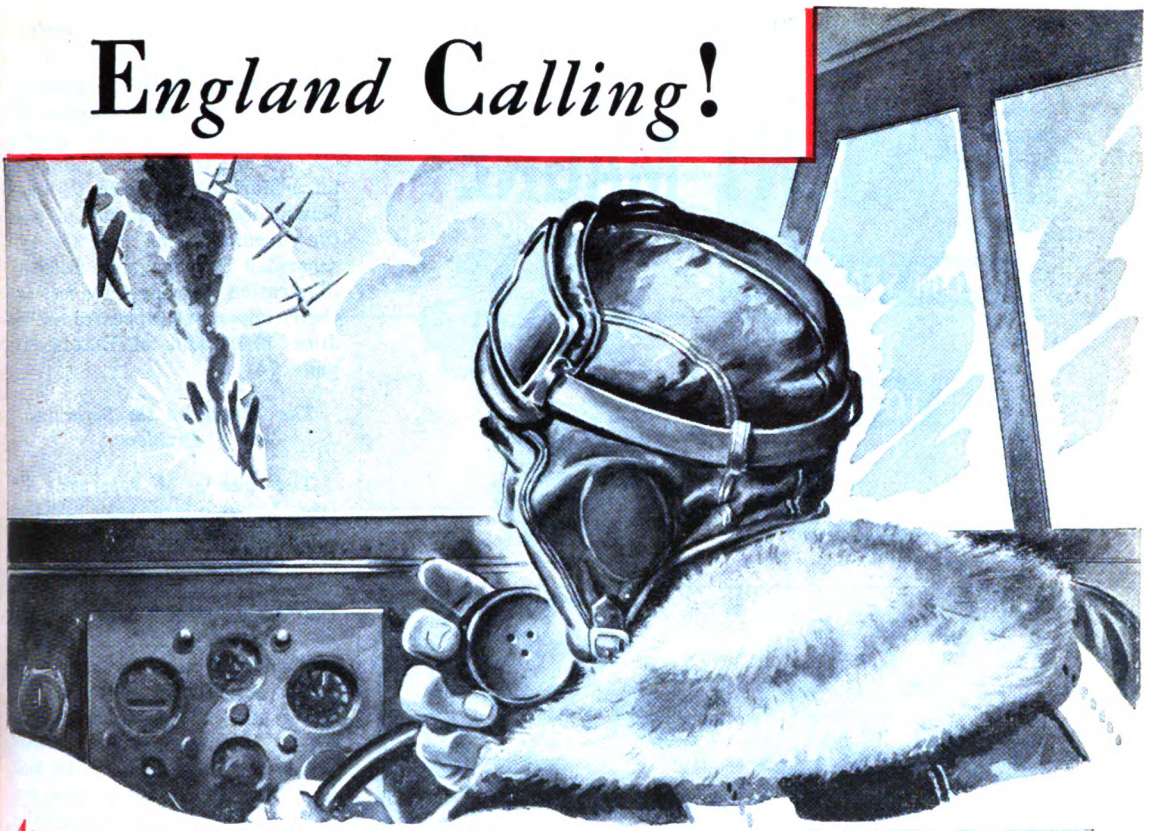
England Calling!



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The American aircraft industry knows what Englishmen meant when they said *so many owe so much to so few.* For it was our aircraft industry that squeezed out every available plane to add to their own so that England could fight.... and win the Battle of Britain in 1940.

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This control unit was one of many pieces of equipment built for intercommunication in British airplanes.

To determine most efficient antenna for VHF communication Pacific Division is testing numerous types.

Interior of Pacific Division's mobile laboratory used in VHF communication development program.

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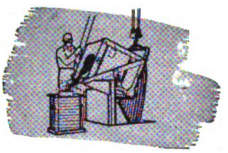

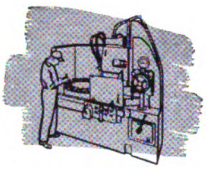

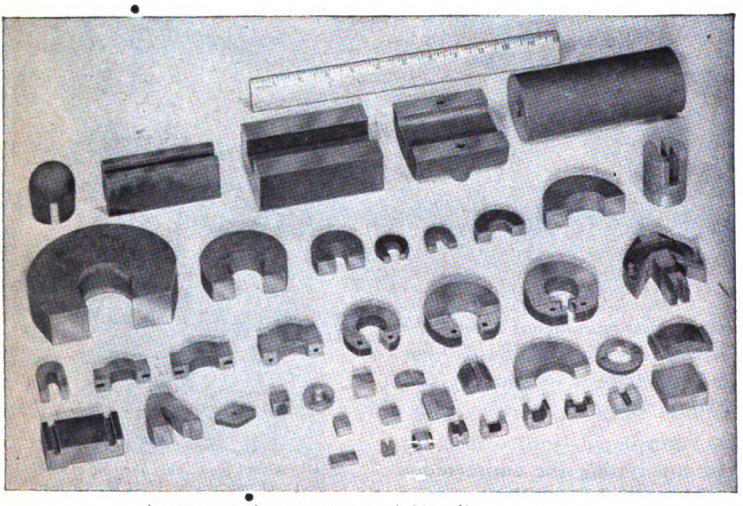

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SPECIALISTS IN THE MANUFACTURE OF ALNICO PERMANENT MAGNETS

tric Company, K. H. Kingdon and H. C. Pollock, have separated U^{235} fro[illegible] isotopes using a [illegible] spectrograph. Uranium tetrachloride was heated, the vapor bombarded by electrons to form the uranium ions and the ions separated by a magnetic field. An illustration showing these men and their apparatus appeared in the June 1940 issue of ELECTRONICS, page 74.

The Attack on the Separation Problem

The means of separating U^{235} from U^{238} on a large scale have been under active consideration during the last year. Chapman as long ago as 1917 suggested that separation of isotopes by weight might be accomplished by means of "thermal diffusion", an effect which takes place when convection currents are induced in a gas composed of particles of different weight. Clusius and Dickel built an apparatus for the purpose, consisting of a heated wire running on the axis of a vertical tube containing the gas. Brewer and Bramley[3] used two concentric vertical tubes the inner one heated, the outer cooled, and passed gas through the space between the walls of the tubes. Furry, Jones and Onsager[4] of Harvard and Yale worked out the theory of the concentric tube device, but did not consider its use in the uranium problem. Recently Krasny-Ergen[5] of the Wenner-Grens Institute in Stockholm applied this theory to the uranium problem. He considered two concentric vertical tubes 10 meters (33 feet) long, the inner tube 4 cms in diameter, with 1.34 mm distance between the walls of the tube. The inner tube is heated uniformly to 393° C, the outer kept cool at 60° C. The space between the concentric tubes is filled with uranium fluoride, UF_6, at one atmosphere pressure. In such an apparatus the lighter U^{235} tends to collect at the top, where it is caught in a chamber. The calculations indicate that if the upper chamber were allowed to come to equilibrium and the gas drawn off (discontinuous operation), the concentration of U^{235} would increase

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guide to the best use of plastics in postwar radios

New plastics with new properties and older plastics with improved formulations pose a real problem today for every designer of postwar radio and electronic equipment who is responsible for getting full advantage out of his material opportunities.

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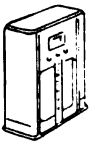


CONSOLE CABINETS
Thalid impression molding

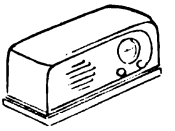
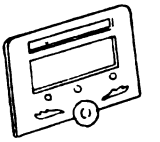
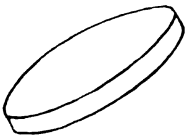


TABLE MODELS
Cerex • Resinox



ESCUTCHEONS
Thalid impression molding
Fibestos • Lustron • Resinox



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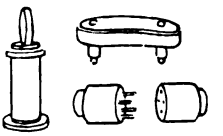
Lustron



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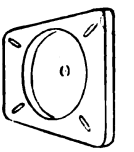
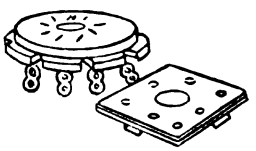


SPEAKER CONE ASSEMBLIES
Resinox bonded pulp and paper
Thalid impression moldings



TUBE SOCKETS
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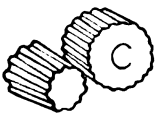
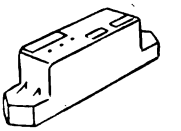
Laminates of Resinox



CONTROL KNOBS
Fibestos • Lustron • Resinox



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FIBESTOS (cellulose acetates)	good to excellent	excellent	to 120—160° F.	fair to good	good	unlimited	MC, S, R, T	I, C, E
LUSTRON (polystyrene)	good	good	to 180° F.	excellent	excellent	unlimited	MC	I, C, E
NITRON (cellulose nitrates)	very good	excellent	to 140° F.	good	fair	unlimited	S, R, T	Special methods
RESIMENE (melamine-formaldehydes)	very good to excellent	good	to 210—380° F.	excellent	excellent	all but lightest colors	MC, IR	C, T
RESINOX (phenol-formaldehydes)	good to very good	good to excellent	to 230—450° F.	excellent	good to excellent	darker colors only	MC, IR	C, T
STYRAMIC HT (Polydichlorostyrene)	good	good	to 236° F.	excellent	the best	unlimited	MC	I, C, E
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*MC—molding compounds S—sheets R—rods T—tubes IR—industrial resins
**I—injection C—compression E—extrusion T—transfer, form of compression

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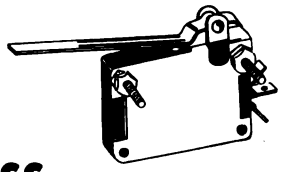

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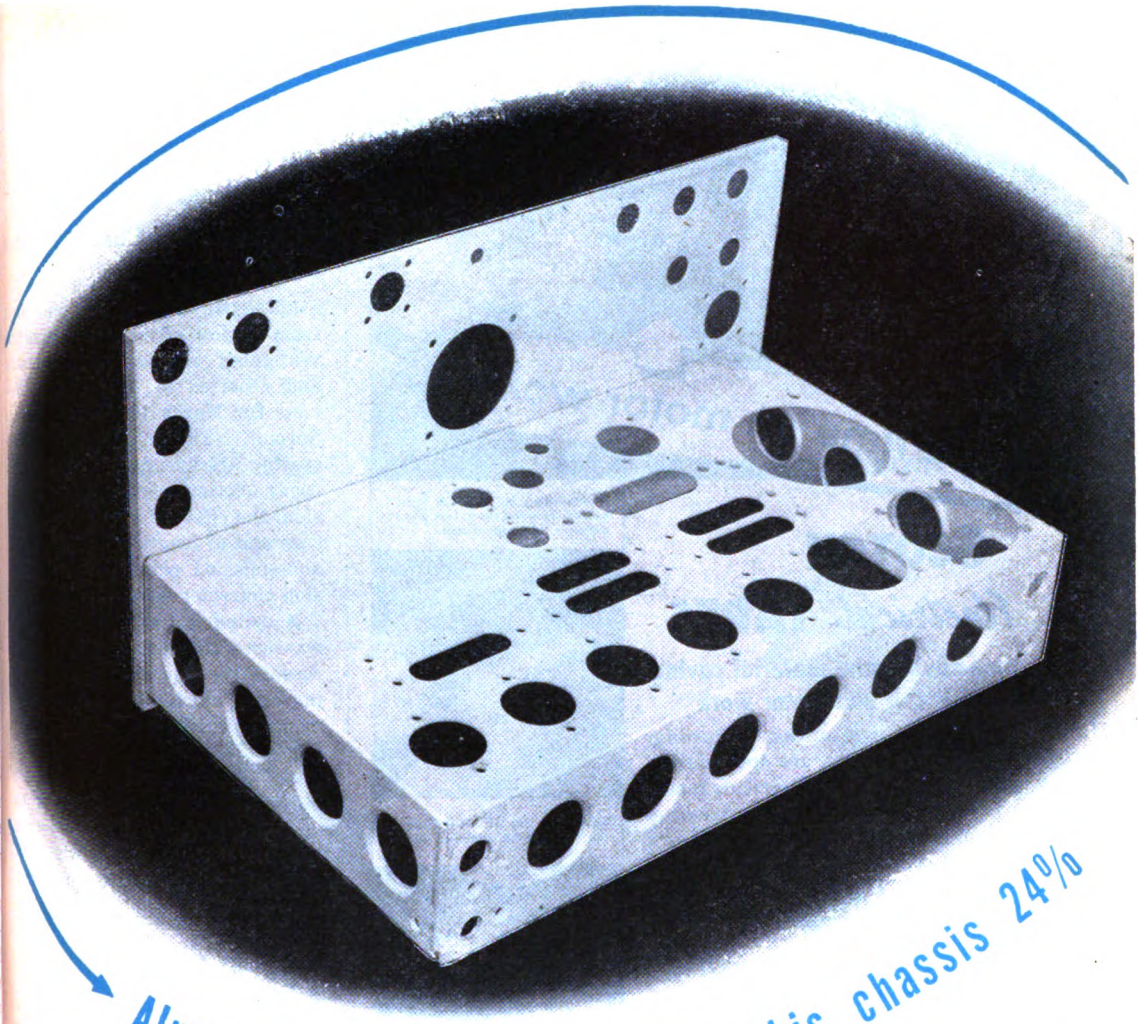

Aluminum reduces weight of this chassis 24%

Photograph courtesy of Airadio, Incorporated, designers and manufacturers of radar and electronic test and communication equipment.

Before it was redesigned by Airadio, Incorporated, Stamford, Conn., this chassis for radar equipment weighed 17½ pounds. Made with Alcoa Aluminum the weight was reduced to 13 pounds and 5 ounces.

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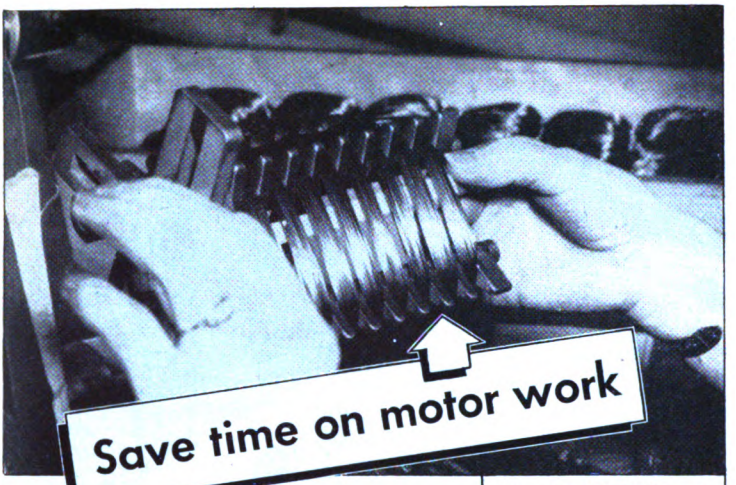

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Review, March 15, 1940 (Vol. 57, p. 546).
3. Brewer and Bramley, *Physical Review*, 55, 509A (1939).
4. Furry, Jones and Onsager, *Physical Review*, June 1, 1939 (Vol. 55, p. 1083).
5. W. Krasny-Ergen, Letter to the Editor, *Nature*, May 11, 1940.
See also an article in *Electrical Engineering*, February 1940, by Enrico Fermi.

• • •

Pulse Emission Characteristics of Oxide Cathodes

SHORT-TIME THERMIONIC emission from oxide-coated cathodes was investigated at Cornell University and reported in the *Physical Review* for March 1945 by Robert I. Sproull. The effect of cathode-coating thickness on emission, the decay characteristic during emission, the effect of cathode temperature and of length of emission and non-emission periods on the emission character were studied.

A cylindrical experimental diode was used for measurements. Representative types of cathode coating upon which measurements were made are given in the accompanying table. Cathode temperatures were observed with an optical pyrometer. Plate voltage for the diode was supplied by a rectangular wave generator in which the period and the relative duration of

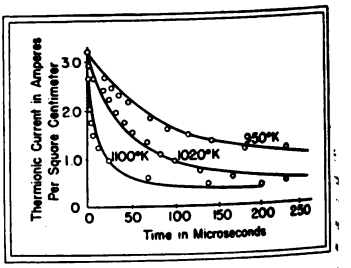

Fig. 1—Measured decay characteristics of tube No. 11 at different temperatures are shown by circles; lines show theoretically calculated curves. Data and calculations were normalized to start at the same initial current

positive and negative parts of the cycle were variable in steps. To avoid spurious interference, the multivibrator oscillator generating these pulses was synchronized to the power line, and all power supplies were electronically regulated.

A special peak-reading comparison vacuum-tube voltmeter with a calibrating pulse source was used to measure the decay characteristic of the emission pulse current.

Observed emission behavior is

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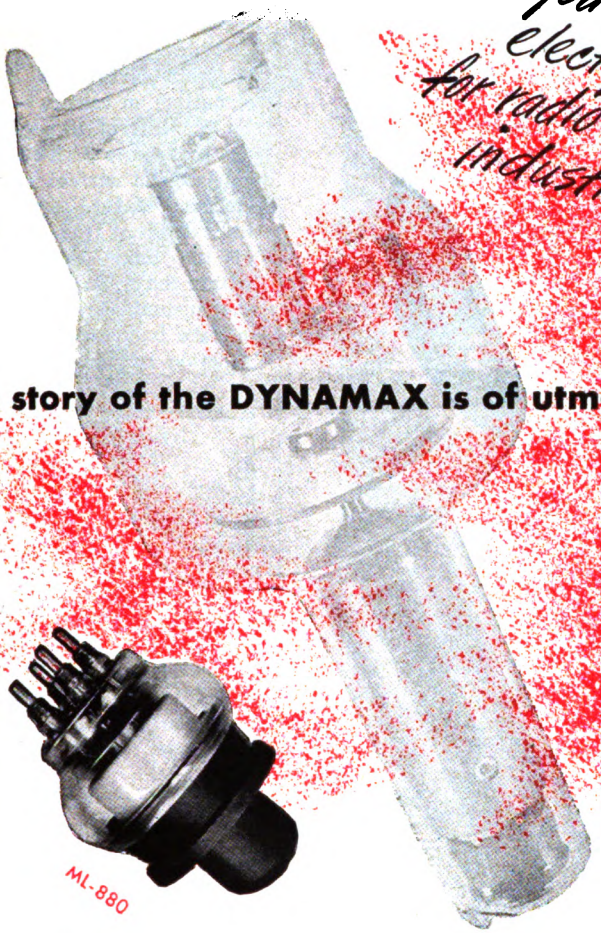

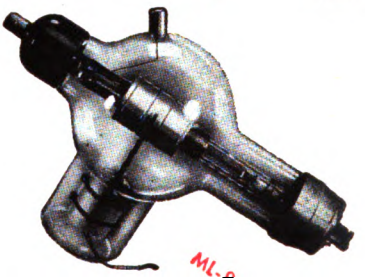

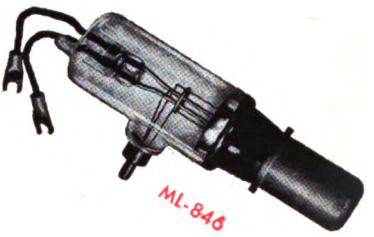

WHEN first announced, in 1938, the Machlett Dynamax represented the solution of the most difficult problems ever encountered in electron tube manufacture—paralleled only by the Machlett VM-1, the first precision, sealed-off, 2,000,000-volt dc tube.

The Dynamax was designed to meet the demand for a dependable, high-capacity X-ray tube that would give much sharper definition under the most adverse conditions. The desired results could be obtained only by using a very small focal spot, and an electron beam of high energy, 100 KV, .5 amp. Concentrating so much energy on a small spot meant destruction of target and tube unless the heat could be dissipated. Rotating the target was found to be the most effective means of protection, but this produced a much greater problem, that of lubricating the motor bearings inside the envelope without impairing the vacuum through distillation of the lubricant. A novel method of coating the bearings with a film of pure metallic silver was developed by Machlett engineers, with the result that the weakest spot became the strongest.

Today, Machlett rotating-anode tubes give over 200,000 exposures, over ten times the normal life expectancy of X-ray tubes of only a few years ago, and *more than twice that of present-day conventional stationary-anode tubes!* This is the preferred type for use in mass health surveys and busy institutions where the load is too great and too constant for any other tube. You will be interested in the full story of the Dynamax—write for your copy today; it will be sent with our compliments.

True enough, the Dynamax is an X-ray tube—but all electron tubes are brothers under the skin. The engineering talent, the techniques and the manufacturing skill which produced the first really successful rotating-anode tube are the same that now guarantee the performance and advanced features of all Machlett electron tubes, for all purposes, whether in the fields of radio or industry. It will pay you to use this background of electron tube engineering and production skill by choosing a Machlett when you need an oscillator, amplifier, modulator or rectifier. Machlett Laboratories, Inc., Springdale, Connecticut.

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explained on the theory that, under the influence of the electric field that draws off electrons from the emission surface, the barium (or strontium, or calcium) ions formed by the loss of emission electrons are induced to drift from the outside crystal surface back into the emission layer. (Measurements indicated that from 5 to 50 percent of the total conduction current within the crystals is ionic). Thus the instant emission begins, the surface is covered with low work-function barium atoms, but after

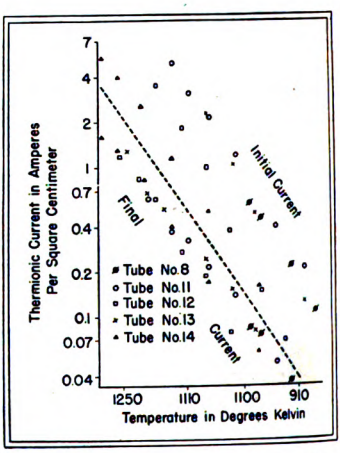

Fig. 2—Initial and final current values for various tubes at different temperatures

a short period of emission the surface is composed of ions and atoms thus having an apparently higher work-function. Equilibrium is reached when the rate of inward ionic diffusion and creation of ions at the surface are equal. Equations for the decay from initial to final value of the emission current derived from this theory check with observations as shown in Fig. 1.

Effect of Pulses

To determine the dependence of emission decay on the duration and repetition rate of pulses, emission duration was varied from 100 to 300 microseconds at a repetition rate of 30 pulses per second. No change in decay rate was observed. Repetition rate was varied from 20 to 120 pulses per second at an emission duration of 300 microseconds, and no change in decay

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rate was observed. However at a frequency of 600 cycles per second, the ratio of initial to final current was reduced about 20 percent indicating that the surface did not

Table—Composition and thickness of typical coatings used in the tests

Tube No.	Composition (by weight in %) BaO	SrO	CaO	Thickness (mg/cm²)
8	50	50		1.2
11	50	50		5.2
12	50	50		9.0
13	60	30	10	32.0
14	50	50		0.8

have sufficient time to recover from its partially ionized state. This test was conducted on tube No. 8 at a cathode temperature of 920 degrees Kelvin.

Effects of temperature are given in Fig. 2. Decay was found to be independent of the oxide coating thickness within the range of thickness indicated in the table.

• • •

Navy Radio-Technician Training

By RUTH LAWYER
Editor, Technical Education News
McGraw-Hill Book Co., Inc.

TO TRAIN OPERATORS and service men for the multiplicity of electronic equipment carried by Naval ships and planes, the Navy is conducting an enlarged, accelerated technical training program. Bellevue, the permanent Navy Radio Materiel School, shares with the Naval Research Laboratory a site on the Potomac a few miles from the center of Washington. Three other temporary schools—Treasure Island, San Francisco; Navy Pier, Chicago; and Corpus Christi, Texas (the latter devoted to training in airborne equipment)—carry on similar programs.

At Bellevue, there is a staff of 168, a student enrollment of 1900, with 135 new men entering every two weeks.

All the faculty have been through the school themselves. Commanding officer Comdr. Raymond Cole, USN; executive officer Lt. Comdr. Nelson M. Cooke, USN; and technical training officer (corresponding to dean of students) Lt. F. C. Atnip, are familiar from years of experience with the ways of the Navy. Intercom systems connect

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3. Furnishes you with a relatively inexpensive method of operation during the transition period.

4. Does not have to be discarded—it will become the future amplifier portion of the new transmitter. An Armstrong phase shift modulator can then be supplied by us, which, when added to the power amplifier section of the converter will constitute a complete new one or three KW transmitter.

Consult us immediately for prompt delivery of your order, pending lifting of present restriction.

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Its load chamber is only 14" from top to bottom—hence a minimum temperature gradient between those points. This assures uniformity of cold treatment throughout the load and avoids thermal shock in work parts—no checking or fractures.

In addition, the load chamber is long enough (either 25" or 55") so that work parts may be laid flat instead of being processed vertically—another assurance of uniformity.

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No trouble due to trapped oil in the evaporator because this unit includes a Serpentine evaporator, the only one that cannot short-circuit.

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department and division offices, showing that the school not only teaches electronics but also uses electronics.

During the seven months' work, students attend lecture, laboratory, and supervised study in the ratio 4-6-2. Work is so scheduled that each man has an opportunity to work with each piece of equipment. Most of the students' time is spent in the advanced laboratory-shop, although they acquire underlying theory at the same time. The United States Armed Forces Institute has evaluated the work as the equivalent of twelve semester hours of college credit.

Matriculation

Students are selected from the upper twelfth of the enlisted men. Entrance requirements are high with the result that only about three percent flunk out because of academic failures. Most of the entering men are high-school graduates and more than half have had some college training.

Aptitude rather than previous schooling is the basis for admission. There are general classification

Students use test equipment to study circuit operation. In this instance they are observing wave shapes throughout a d-c amplifier

tests, mechanical and electrical tests, and radio tests. Once past these hurdles, students go through one month pre-radio school, which is primarily for screening, orientation and basic training. They then go to a three-month elementary electronics and radio materiel primary school of which there are six scattered throughout the country. At these schools, the men are given

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Breadboard layouts are used to fa miliarize students with basic circuit operation before they service and op erate standard Naval gear

learn about transmitters (of low-, high-, very-high-, and ultrahigh frequencies) so that they can, for instance, set up and operate a porta able transmitter on a beach during an invasion. They also study power supplies and control circuits.

DIVISION 3: Receivers are stu died in a new soundproofed labora atory. Instructors put faults into the equipment and the student trouble-shoot until they have lo cated and corrected the faults. Stu dents learn about transmission-lin theory, installation, and cable test ing. They study directional antenn arrays and direction finders.

DIVISION 4: The students stud sonar (Sound Navigation An

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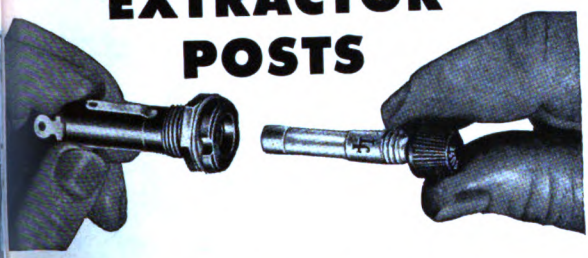

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Sonar, used in su fare, depends upon th ersonic frequencies the water. Students install and operate th Units are installed f tion, often necessitat by the maintenance ate shipboard operati

Recently installed ment is built into a rangement with recei on the upper deck, t equipment and driver deck, and the superson ectors submerged in a

DIVISION 5: The a these same echo princ died in connection wit dio Direction And Ra

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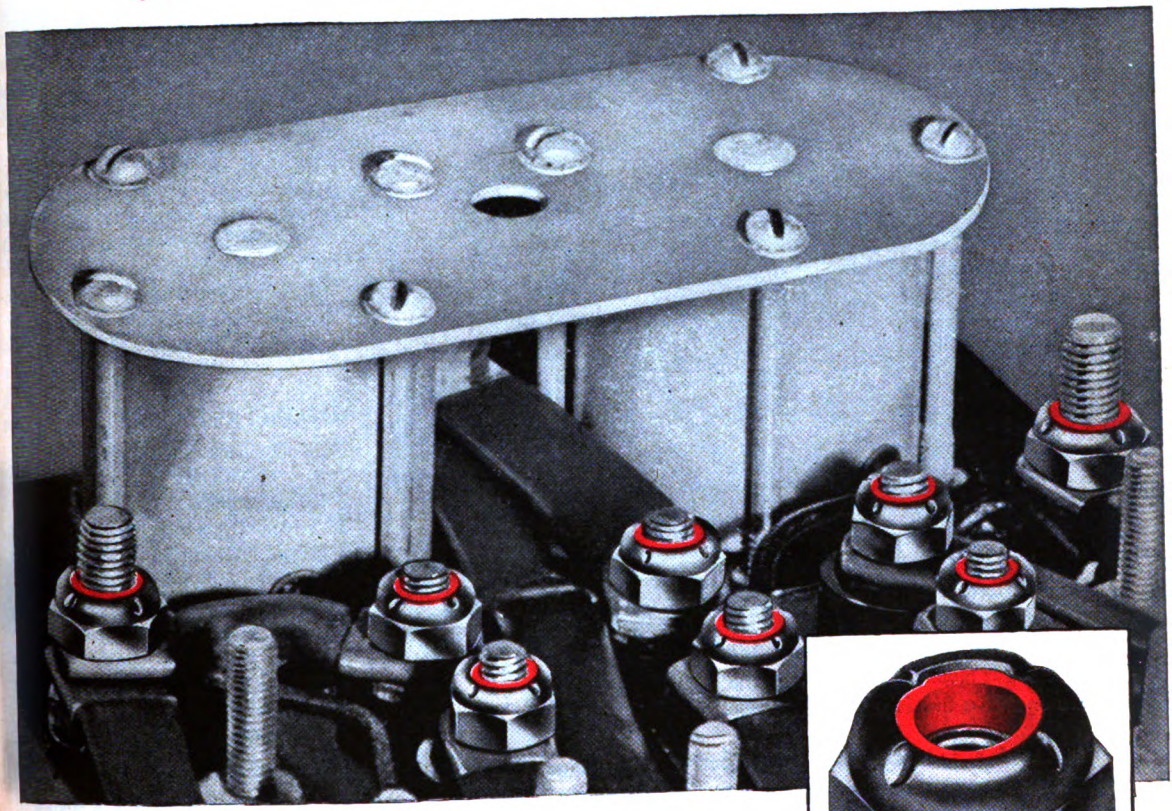

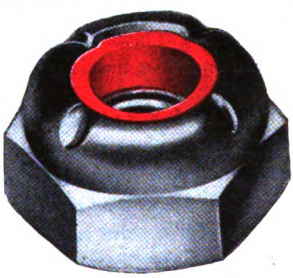

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With the assured high conductivity of a soldered connection, combined with the great advantage of easy removability for servicing and overhaul, Elastic Self-Locking Stop Nuts are being given new responsibilities in the field of electronics every day.

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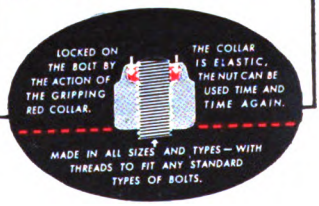

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Rotary speeds from 600 to 600,000 RPM — or vibrations from 10 to 10,000 CPS — can be "stopped" and studied with the Model 1200 Stroboscope. The light source is mounted in a small probe at the end of a five-foot flexible cable.

This makes it easy to examine small objects at close range. Provision is made to operate the unit from external tuning fork or crystal standards, where extreme accuracy is required. The motion of objects moving at irregular speeds may also be "stopped" with the Model 1200. An accurate repetitive pulse rate is obtained, as the pulses are derived from a stable audio oscillator.

Not only does this eliminate the necessity for constant readjustment of the repetitive rate, but it also insures clearly defined images at high speeds.

For greater flexibility, a light intensity control switch is also provided. This enables the user to control both the intensity of the light and the duration of the pulse length.

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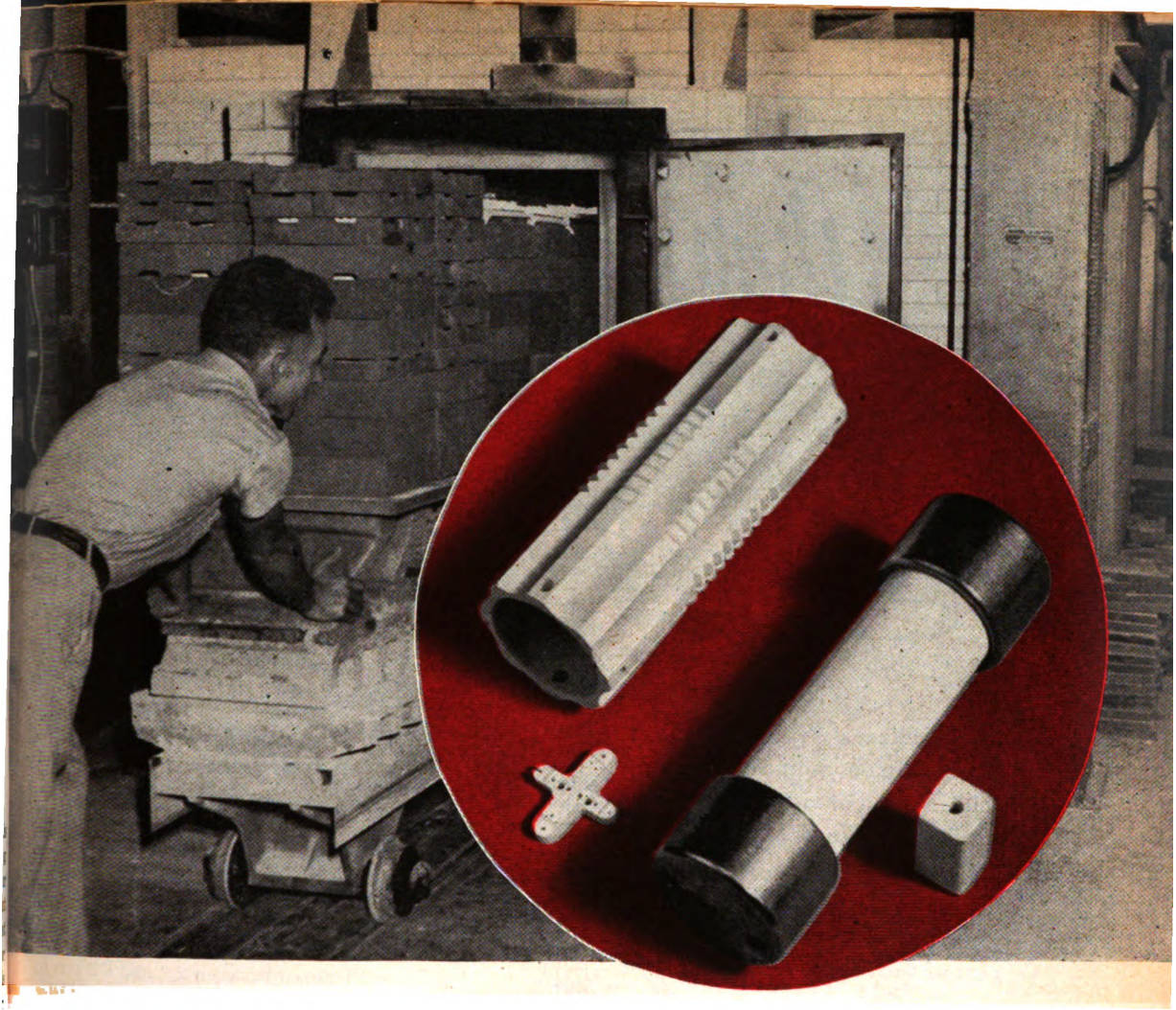

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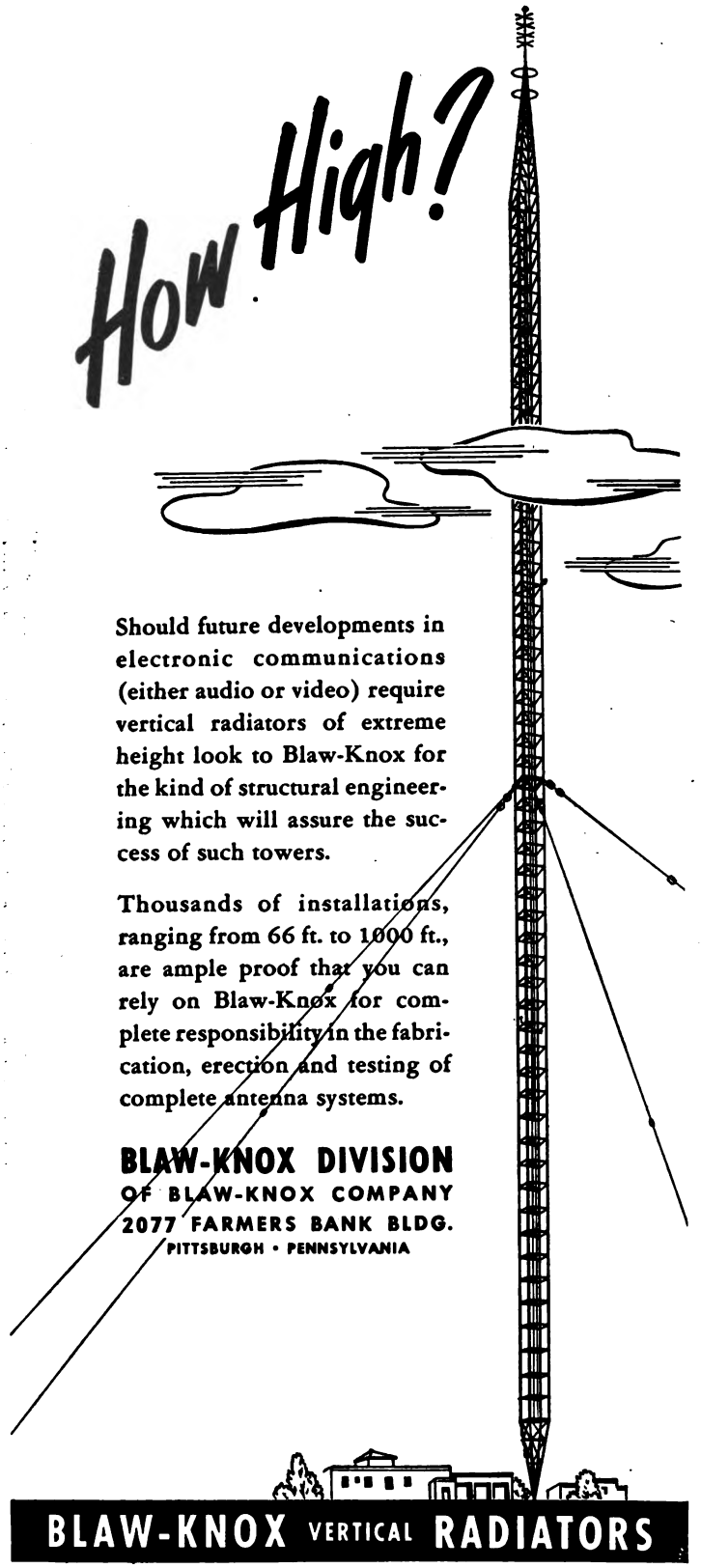

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BLAW-KNOX VERTICAL RADIATORS

when two voltages are known; enter the graph at the left at the higher voltage, follow the diagonal downward to the right until the ordinate of the lower voltage is reached, the abscissa of this point gives the number of decibels corresponding to the ratio of the two voltages.

If the input voltage is larger than the output voltage, the db valve is, of course, loss; if the input is smaller than the output, the valve is gain. Currents are treated similarly to voltages. If powers are given instead of voltages or currents, divide the final db by two. If ratios are given, simply assume that the ratio is the first voltage, current or power, and that the second one is unity.

• • •

Generation of Millimeter Wavelengths

A METHOD OF PRODUCTION, detection and measurement of extremely short electromagnetic waves is described by Jean P. Cooley and John H. Rohrbaugh in the *Physical Review* for May 1 and 15, 1945.

Waves were produced having lengths between 2.2 and 0.2 mm by using small aluminum particles, suspended in a continuously flowing stream of oil, as dipole radiators. A shock excitation circuit was used generating 1000 surges per second of steep wave front and short duration. These pulses were applied to a 1-cm gap containing the oil stream to supply the necessary electric field.

Detection was accomplished by a bismuth-antimony thermopile which had all junctions covered with a 2-mm coating of 50 percent lamp black and 50 percent tellurium-plated cork dust. The output of the thermopile was fed to a galvanometer whose output was amplified electronically and optically.

—◈—

Playback over a loudspeaker of recorded mating calls of mosquitoes attracts them to insect traps placed where the sound originates, recent experiment at Cornell University Medical College show.

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Upside down and sideways—and this transformer puts in overtime!

This is just one more reason why Thermadors are known as America's quality transformers.

There is a machine called a Shaker. It goes up and down while it rotates. The motion varies from a gentle rhumba to an earthquake of cataclysmic proportions. In 10 minutes an ordinary transformer sails off into the steel mesh net.

At Aireon Manufacturing Corporation's Kansas City plant they bolted a Thermador transformer to the shake-bed of this machine. They turned the shaker on for an hour—then they left it going overnight, unbolted the Thermador transformer, connected it to the test line. The needle showed not an nth of variation.

Why this incredible performance? Just this. Transformers were formerly mounted to the cover of their cases. Thermador developed a strong stamped bracket from strip steel and projection-welded it to the case body—independent of terminal boards or covers. As a result, Thermador transformers can be mounted in any position—up and down and sideways—and take the worst beating you can give them.

THERMADOR ELECTRICAL MANUFACTURING COMPANY
5119 SOUTH RIVERSIDE DRIVE • LOS ANGELES 22, CALIF.

Thermador Transformers

DEFEAT COLD • HEAT • HUMIDITY

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NEWS OF THE INDUSTRY

News of Washington; actions by the Federal Communications Commission; notes on meetings ahead; activities businesswise; and information about people you know

Japanese Quality

ACCORDING TO A REPORT by OWI, Japanese airborne electronic equipment made since 1940 is far superior to that of earlier design and actually is of excellent workmanship and material. Much aluminum is found in their designs providing unusually light gear. No precautions were found to have been taken in corrosion and fungus control, however.

Radio direction finders, standard equipment on medium and heavy bombers, were not reported to have been normally installed in fighter ships. Several Japanese Zero fighters have been found with radio equipment which had been made in the United States, in whole or in part, while components of German and British manufacture have been reported in units of Japanese manufacture.

All equipment reported on was hand made, with no evidence of quantity production.

Radiotelephones for Vehicles

APPLICATIONS have been filed with the Federal Communications Commission by the American Telephone and Telegraph Co. for authority to install radiotelephone stations to provide two-way voice communication with drivers of motor vehicles in Baltimore, Chicago, Cincinnati, Columbus, Denver, Houston, Milwaukee, New York, Philadelphia, Pittsburgh, St. Louis, Salt Lake City, and Washington, D. C.

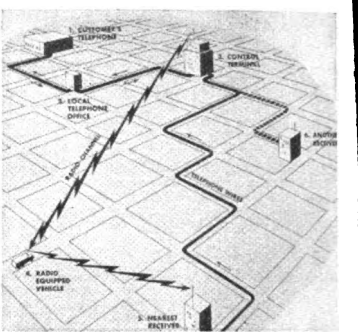
The Bell System companies, planning to make the new service available first where public necessity is greatest, are making surveys to determine the need for and the feasibility of mobile radio telephone service in many other cities of the country.

In metropolitan centers, the plan is to use transmitters of about 250 watts power operating in the band between 152 and 162 megacycles. Receiving stations are to be located at various points to pick up signals from the 15-watt mobile units. The path of a typical call is shown in the illustration. Each mobile unit will use a single antenna for both sending and receiving.

Calls to and from motor vehicles will be handled by special operators, the calls traveling part of the way by wire and part by radio. A caller at her desk dials or asks for the vehicular operator and gives her the call number of the vehicle. By dialing a code number, she causes an audible or visual signal in the vehicle to indicate to the driver that he is wanted.

The operator of a mobile unit can originate calls by picking up the telephone and pushing a button to signal the vehicular operator.

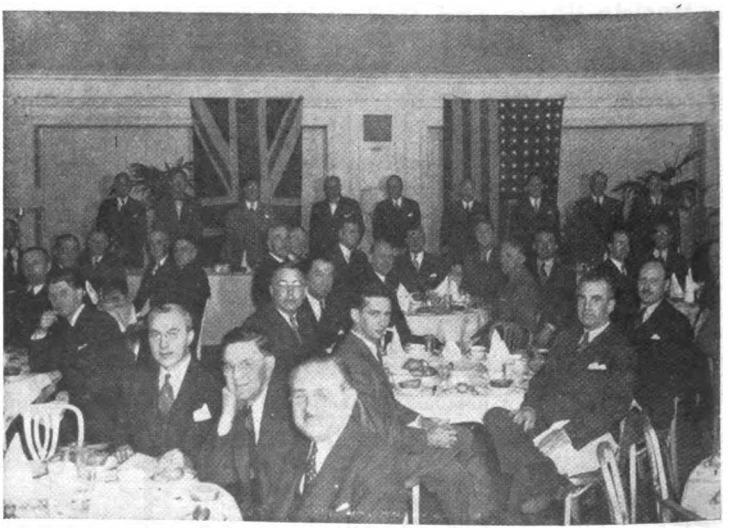
Another type of radiotelephone service which will be tried, would furnish two-way voice communication with motor vehicles operating on inter-city highways and boats on adjacent waterways. This service would require both transmitting and receiving stations along the highways to be served.



Currently proposed urban mobile radiotelephone system with central 250-watt transmitter to contact vehicles and several receivers located at various points to receive calls from the low-powered vehicular units

F-M Converters

ANNOUNCED AT A MEETING of the pioneer f-m radio manufacturers in New York recently is a new unit capable of providing f-m broadcasters with simultaneous transmission on frequencies in both the present 42-50 mc and the new 88-106 mc bands. New receivers are being designed with two f-m bands



Members of the U. S. and the Canadian RMA gather at luncheon in Montreal's Mount Royal Hotel

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Unusual FACILITIES FOR UHF DESIGN AND POST-WAR PRODUCTION

Two things are vitally necessary for the design and production of UHF equipment . . . specialized knowledge and special equipment. We have both. Lavoie engineers are highly specialized along UHF lines. In our plant, the equipment and shop practice are centered on UHF requirements.

Lavoie service is available to you either in the form of technical recommendations only, or we can develop your ideas in actual physical form. This applies to absolutely new ideas or to the betterment of present ideas. We invite consultation.

UHF HARMONIC FREQUENCY GENERATOR

PROVIDES output voltages which are multiples of 10 or 40 megacycles with CRYSTAL-CONTROLLED accuracy.

RECOMMENDED FOR: the calibration of receivers, wavemeters, or using internal beat detector for calibration of oscillators and signal generators.

UHF PRECISION FREQUENCY METER

Completely portable
Accuracy 0.1%
Battery or
AC-Operated

Models available from 100 to 1500 megacycles with 2 to 1 frequency coverage on each model Available only on high priority.

U H F

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists *in* The Development of UHF Equipment *and in* The Manufacture of UHF Antennas

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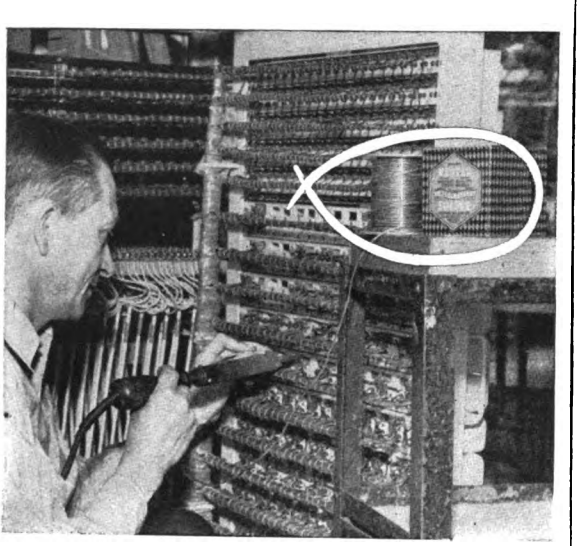
Match Fine Workmanship with Materials that LAST!



KESTER CORED SOLDERS

Assure Permanence

→ Workmanship is only as good as the materials used! Workmanlike soldering requires an accurately compounded, pure, balanced solder — one that holds tight against bending, vibration, shock, contraction, and expansion. Kester assures such permanence!

→ Kester Cored Solders are unexcelled for high quality and unvarying uniformity. Kester's 46 years research and practical experience gives you the right, permanent solder for every type of work.

→ Virtually mistake-proof, Kester Cored Solders are applied in one simple operation because the positive acting flux is contained right in the core — forms tight, clean solder-bonds, sure to stay put!

→ Specify Kester Rosin-Core Solder for electrical connections — Kester Acid-Core Solder for general work. Both are available in a wide range of core and strand sizes. Consult Kester Engineers, without obligation, on any soldering problem you may have.

KESTER SOLDER COMPANY
4204 Wrightwood Avenue Chicago 39, Ill.
Eastern Plant: Newark, N. J.
Canadian Plant: Brantford, Ont.

to provide reception in both the present and new channels. The transmitter converter is applicable to transmitters of any manufacture, supplies 1 or 3 kw output power at any frequency in the new band, requires no additional monitoring, and is supplied by Radio Engineering Laboratories, L. I. C., N. Y.

Good Engineering Practice

PROPOSED STANDARDS have been drawn up by FCC to serve as a basis for discussion of good engineering practice by f-m broadcast stations. They have not been approved by the commission.

Included in the contents of the notice announcing the proposals are: engineering standards of allocation; topographical data; interference standards; field intensity measurements in allocation; transmitter location; antenna systems; standard lamps and paints; transmitters and associated equipment; indicating instruments; auxiliary transmitters; operating power—determination and maintenance; frequency and modulation monitors at auxiliary transmitters; requirements for type approval of transmitters, frequency monitors, and modulation monitors; approved transmitters, frequency monitors, and modulation monitors; and application forms.

Hearing Aid Standards

AFTER EIGHTEEN MONTHS of active compilation and testing, the American Hearing Aid Association, 77 W. Washington St., Chicago 2, Ill., has released a set of specifications covering the scientifically accurate measurement of performance characteristics in hearing aids.

Drawn up by a group of hearing-aid engineers forming a special committee for this purpose, the original recommendations were tested by being put tentatively into actual practice in the laboratories of manufacturers. Experiences were reported back to the committee and modifications made.

It is the expectation of AHAA that the material will eventually be issued by American Standards Association, perhaps in expanded form. The present publication, copies of which can be obtained

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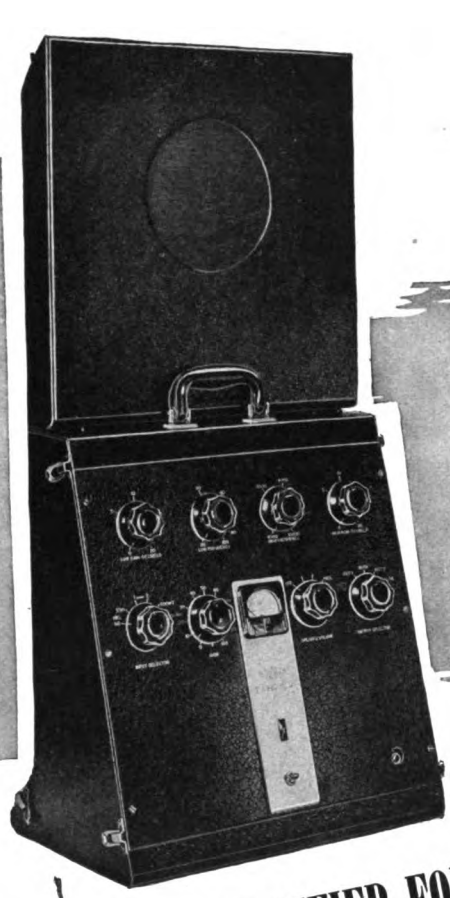
IMMEDIATE DELIVERY!



Unit 540

a limited number of Fairchild AMPLIFIER-EQUALIZERS!

UNIT 540 is the latest model Fairchild Amplifier-Equalizer. Its design permits the unusual operational advantage of *unlimited frequency selection* over two critical ranges: 20 to 100 cycles; 4,000 to 10,000 cycles with an available boost of 0 to 20 db.

Unlimited frequency selection compensates for brilliance-loss at the slower 33.3 speed and for response-deficiencies of cutterhead, disc material, pickup or speaker by electronically boosting the higher frequencies from 4,000 on up to 10,000 cycles – with a negligible effect on volume and without loss in the bass.

Unit 540 can be used with two recorders to record or play back continuously by switching from table to table; to make two identical records at the same time; or to 'dub' from one table to the other as in copying a recording played on one table and recorded on the other.

Unit 540 is compactly designed to fit into a light-gauge metal trunk measuring 17″ x 18″ x 11″. It can also be rack mounted. And provision has been made in the inputs and outputs to permit operation under many varying conditions – to meet the exacting professional requirements of the radio and communications fields.

Descriptive and priority data are available. Address *New York Office:* 475 – 10th Avenue, New York 18; *Plant:* 88-06 Van Wyck Blvd., Jamaica 1, New York.

Fairchild CAMERA AND INSTRUMENT CORPORATION

SOUND EQUIPMENT

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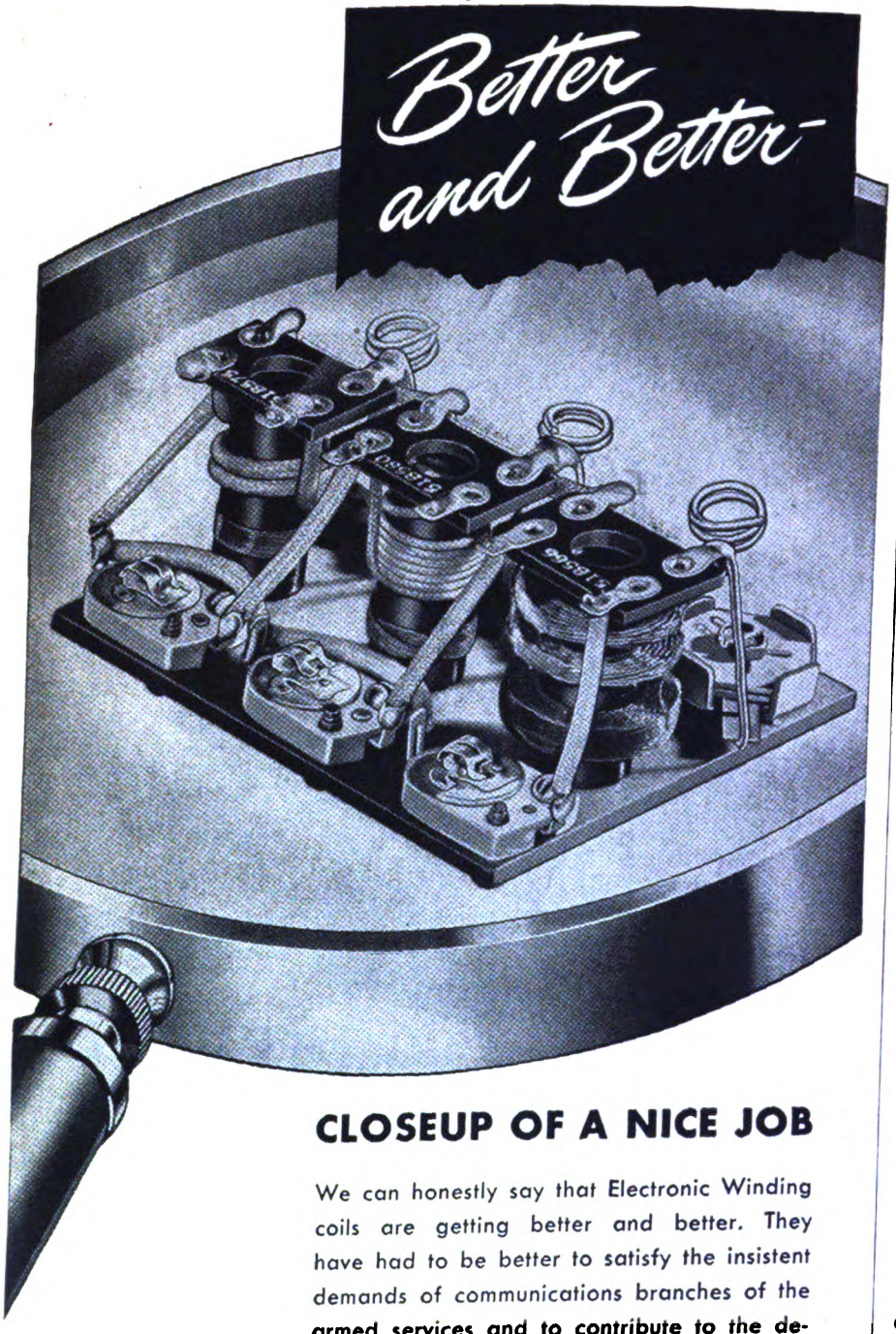

CLOSEUP OF A NICE JOB

We can honestly say that Electronic Winding coils are getting better and better. They have had to be better to satisfy the insistent demands of communications branches of the armed services and to contribute to the dependability of rugged radio equipment that is helping to save lives all around the world. This, closeup of a nice job of coil winding shows a complete RF assembly — just one of the many precise jobs we can do. If specifications call for a coil of *extra quality* call on Electronic Winding.

Electronic Winding Co.

5031 BROADWAY
CHICAGO 40, ILL.

★ ★ MANUFACTURERS OF EXTRA QUALITY COILS FOR PRECISION COMMUNICATIONS EQUIPMENT

from the Chicago a
general method of m
tical gain; test room
measurement of sou
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Research and Eq Expenditures

PRAISING THE CONTR
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In other appropriati
General Brehon Some
the following figures,
of dollars for Signal
curement, excluding
ferred to the Air F
April's reorganization.

	1944 Actual procurement	Se P As 31
Ground Radar.....	295,283	
Special Ground.....	42,529	
Ground and Vehicular.....	381,013	
Telephone and Telegraph.....	283,607	
Wire and Cable.....	196,868	
Miscellaneous.....	482,160	
Totals.....	$1,511,380	$1.

FM for Trucks

ACCORDING TO THE PLAN
way Radio, Inc., all mo
moving over America's
may eventually be linked
terminals and with each
f-m radio. The organi
already asked FCC for
to equip 100 Chicago tru
experimental basis.

Advantages are that di

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ANTENNAS ARE DIFFERENT

The antenna of a grasshopper is a streamlined job... sensitive . . . functional . . . perfectly adapted to its use. Today's antennas—for war or peace—must likewise fit the function, be it Radar or communications.

We at the Workshop design and manufacture antennas to meet the most exacting electrical and mechanical specifications. Our facilities, which include electronic test equipment for measuring antenna gain, pattern, and impedance, provide us with fundamental data beyond the reach of the average manufacturer.

If you have an antenna problem in the very-high, ultra-high, or microwave frequency bands, get in touch with us — we are anxious to serve you.

The WORKSHOP ASSOCIATES

Antenna Manufacturers

FOR THE ELECTRONIC INDUSTRY

66 NEEDHAM STREET • NEWTON HIGHLANDS

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FABRICATED PARTS AND ASSEMBLIES OF SOLID AND LAMINATED PRECIOUS METALS

At the advent of war we created an entirely new department for the manufacture of fabricated parts and assemblies. With a half century of experience to draw on, our training in precision work, the care and attention to detail necessary to production of fine decorative parts, the metallurgical experience and the understanding of fine finishing, proved of immense value in meeting the exacting requirements of industrial parts.

This department today is producing such critical items as collector rings, radio and radar parts, aircraft instrument parts, copper finned radiators for power tubes and other specialized fabrications.

Working on the sheet, wire, and tubing which we fabricate in our mill operations, we are able to carry out punch press and deep drawing work, milling, turning, grinding, and drill press operations. In addition, we have facilities for silver soldering and silver furnace brazing and fine polishing.

To assist you in the application of our products to your products we are maintaining a staff of thoroughly experienced metallurgists, chemists, designers and consultants . . . an up-to-date research and testing laboratory . . . and a splendidly equipped tool room. These are all at your service to cooperate with your own staff to the full extent of our facilities.

Your inquiries are cordially invited. Ask, too, for a copy of our new descriptive folder.

START RIGHT with Makepeace PRODUCTS

SHEETS • WIRE • TUBING • SOLDERS
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can be expedited b
trucks while still
traffic during storms
safer by routing tru
roads; and help can b
in cases of accident
failure.

One 250-w transm
jected to serve as a c
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Chicago. A 30-w p
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RMA Activities

WINDING UP the 21st
operations, Radio Ma
Association had a pro
ship meeting in Chic
June. Annual report
lished and have been

R. C. Cosgrove wa
president of RMA for a
while two new vice pre
F. Balcom and George I
elected to succeed David
and Walter Evans. One
tor was elected, H. J.
Machlett Laboratories-
places W. P. Hilliard
Radio.

Speaking of his predi
the postwar future of th
dustry, Cosgrove envisio
crease of 66 percent in e
and a competition so a
price controls would be
unnecessary. During t
months of civilian produ
expects actual losses be
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Membership was brou
new high of 256 by the a
of: Argus, Inc., Ann Arbo
Astatic Corp., Conneaut
Call-A-Phone Mfg., Chicag
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Products, Madison, N. J.; S
Coil Products, Chicago;
Radio, New York; Thomas
ner Steel Products, Ind.; an
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Previously-announced ad
to the roster included the
ing concerns: Armour R
Foundation, Chicago (as
member); ARF Products,

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ENCOMPASSING ALL FIELDS

wherein communications contribute to { SPEED / SAFETY / EFFICIENCY

On all points, Harvey-Wells communications equipment meets the need for high fidelity in transmission and reception.

Through intensive testing methods and exclusive engineering techniques, Harvey-Wells systems have made important contributions to communications in vital war operations. Their wide use by the armed forces is "proof positive" of their ability to deliver completely dependable service.

The unusually high standards fulfilled by Harvey-Wells receivers and transmitters are your guarantee of maximum efficiency in peacetime communications.

SETTING THE PACE FOR PROGRESS IN COMMUNICATIONS

Harvey-WELLS
ELECTRONICS
SOUTHBRIDGE, MASS.

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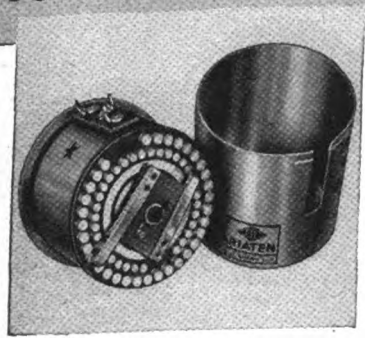
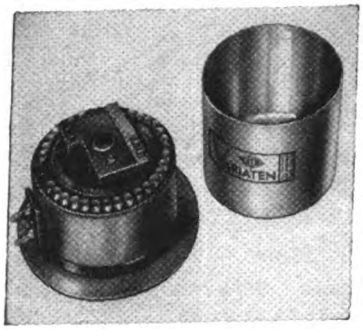
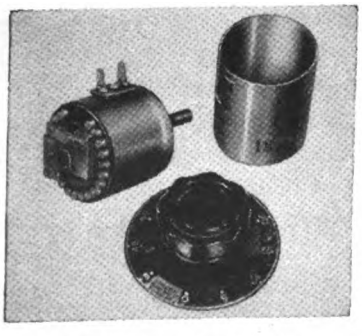
FLAT Contacts
reduce noise, prolong service life



VARIATEN #1218
"T" Circuit—1½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$17.50



VARIATEN #1156
Ladder Circuit—1½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$12.50



VARIATEN #1658
Ladder Circuit—2½ db per step; 30 to 600 ohms impedance. Price, F.O.B...$5.75

VARIATEN contacts and brush surfaces make contact over their entire area because the contacts are ground flat and the brushes stone-lapped, *not* buffed. Buffing produces rounded surfaces and therefore a "point" contact highly susceptible to noise. Variaten brushes move from one contact to the next without rocking motion. The resulting perpendicular spring pressure at all positions allows us to take advantage of the natural resiliency of metals to provide a completely flat contact over the entire brush surface at all times and so reduce noise and lengthen service life.

No carbon resistors are used in any Variaten Mixer...
All are of stable, wire-wound construction. Most are step type. Where quiet operation is the major consideration, we recommend ladder type mixers because the circuit requires only one contact brush operation on the input side of the circuit and any possible brush noise is therefore attenuated along with the signal.

By all means compare circuits, construction and features of these mixers. From the hundreds of Variaten attenuators you may select the attenuators best adapted to your specific needs. Write for the Variaten Catalog today.

VARIATEN

CINEMA ENGINEERING CO.
Established 1935 • Burbank • California

Forest, Ill.; Bell & ... Chicago; Tobe Deutsch... Canton, Mass.; Finch T... cations Inc., Passaic, ... lett Packard Co., Palo ... Jefferson-Travis Radio ... New York City; Perm... cago; The Radio Craf... cago; and The Radiot... oratory, Evanston, Ill.

A reorganization has ... neered by which the ... makers will be transferr... amplifier and sound ... group to the parts divi... tion chairmen in the lat... for 1945-6 are: coils, ... Muter; fixed capacit... Hetenyi; fixed resisto... Stackpole; instruments, ... lett; insulations, John ... metal stampings, S. L. G... tics, John J. Bachner ... Frank Holmstrom; spea... Henry C. Forster; specia... W. R. MacLeod; switch... A. O'Reilly; transforme... A. Hoagland; variable ... Russell E. Cramer; varia... ors, H. E. Osmun; vibra... F. Sparrow; and wire. R. ...

Noise Standards

AMERICAN BUSINESS wil... pate in international work... ards covering the meas... radio noise interference ... ASA (American Standards... tion). Active participat... probably wait until the c... of research now being ca... in this country. But the ... Standards Association ha... to an immediate interch... technical information on ... ject with other countries ... through the United Nation... ards Committee.

RMA Production Cod...

MEETING IN MONTREAL, U.... Canadian RMA boards of d... and officers recently discuss... problems. Among other a... an RMA code was approved ... to be used in identifying ... tion of radio apparatus, a... developed by the data bureau ... RMA engineering departm...

Assignment has been m... three-digit figures to firms r... from 101—Admiral Corp. to ... Zenith Radio Corp. Markin...

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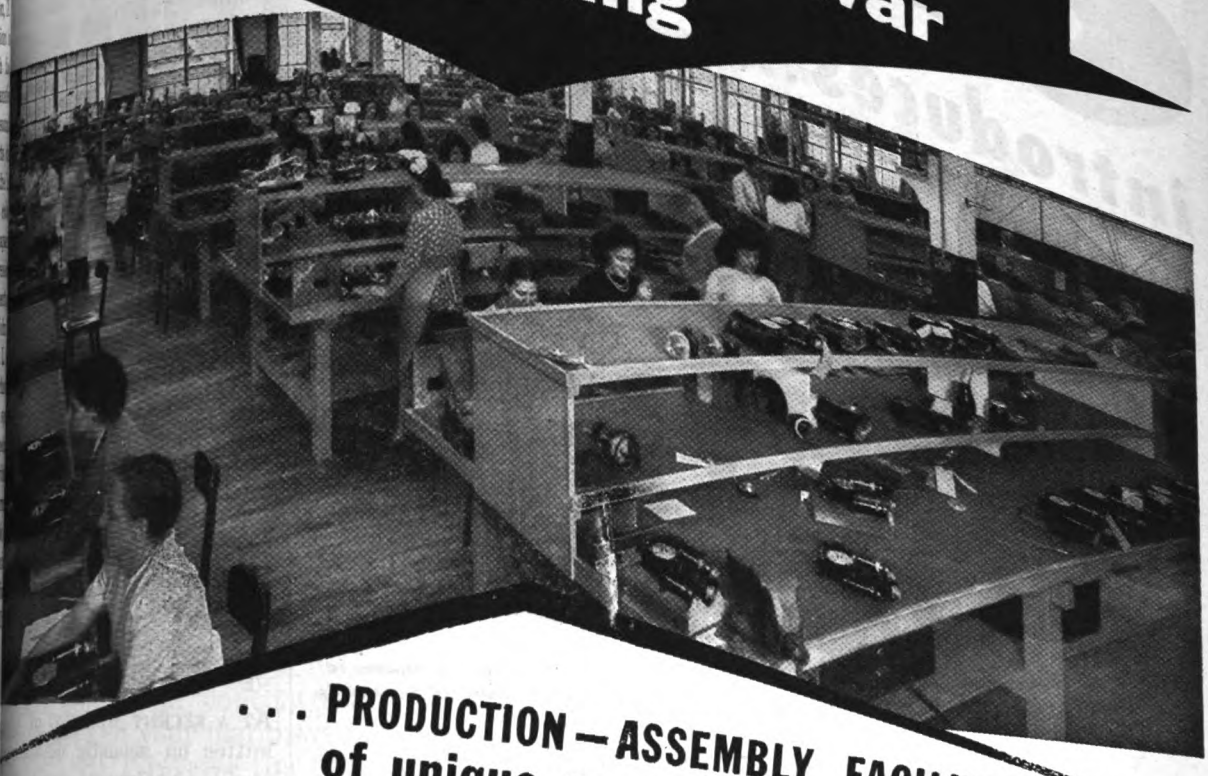
AVAILABLE NOW . . . . AND FOR YOUR post-war planning



. . . PRODUCTION—ASSEMBLY FACILITIES of unique scope and efficiency

THE ATLAS ORGANIZATION, long recognized by leading industrial manufacturers for its ability to handle intricate problems in Engineering, Designing, Tooling and the creation of special Automatic Machinery, now offers an additional service to a few concerns who may require it.

During these war years we were called upon to design, equip and maintain in operation a HIGH SPEED, SUPER-PRECISION assembly department for the production of critical Radar equipment and exceptionally intricate instruments. The important work assigned to us has been, and is now being produced in its entirety, consistently meeting the time schedules and precision standards demanded.

If you have an idea or formulated product which you would like to sub-contract for unit production, we offer the services of a group comprising more than 400 skilled Engineers, Designers and Toolmakers, together with the finest machine, assembly and testing sections available for precise production.

Discussion of this interesting subject with our key men may solve your present problem and possibly get you off to a competitive advantage in postwar production. In other words, may we lift "a load off your shoulders onto ours"? Write or wire for a conference.

ATLAS METAL STAMPING COMPANY
ATLAS TOOL & DESIGNING COMPANY
CASTOR & KENSINGTON AVES., PHILADELPHIA 24, PENNSYLVANIA

. . . . ATLAS DESIGNERS BUILDERS TOOLS AND DIES JIGS AND FIXTURES SPECIAL MACHINERY *a load off your shoulders . . onto ours*

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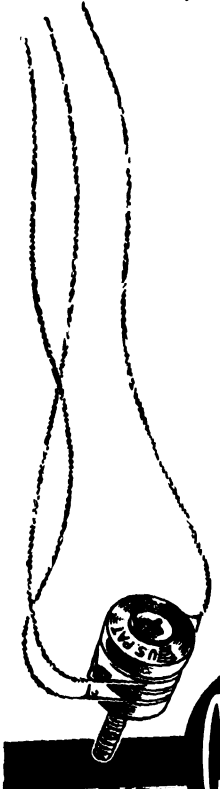
Conant introduces...

*Instrument Rectifier and Balanced Resistance network all combined in convenient plug assembly



Here is a brand-new development by Conant to meet the demand for applications involving the balanced bridge principle in AC operation.

Example: The conversion of standard Wheatstone bridge instruments to AC. In such applications, the AC accuracy and performance are equivalent to DC operation on the same instrument. Null indication is not affected by temperature, frequency, wave form or line voltage fluctuations.

This is but one of the multitude of uses for BALAC (trade mark—patent applied for).

Write or wire today for detailed information.

Instrument Rectifiers

CONANT ELECTRICAL LABORATORIES

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1212 Camp St., Dallas 2, Texas
378 Boulevard N. E., Atlanta, Ga.
[illegible] Greer Ave., St. Louis, Mo.
1526 Ivy St., Denver, Colo.
4214 Country Club Dr., Long Beach 7, Cal
Export Div., 89 Broad St., N. Y. 4, N. Y
50 Yarmouth Rd., Toronto, Canada

start with these three dig lowed by a figure 5 to desig current year and another for example, 21, to design week of production. No members are expected to cluded eventually.

Receiver Licensees

RADIO RECEIVER manufa licenses have been issued b to: Telicon Corp., New Symphonic Radio & E Corp., Boston, Mass.; Harr Co., Los Angeles; Scientifi Products Co., Council Bluffs and Franklin Photographic tries, Chicago.

Record-Changer Stand

WORK IS BEING DONE by th engineering department standardization of record ch pickups, and needles. Bei sidered are proposed dime standards of phonograph for home use, proposed electrical and mechanical sp tions, terminology, and a st warranty.

Speaker Standards

AT A RECENT MEETING of th mittee on acoustic devices receiver-equipment group of ceiver section, RMA engineeri partment, discussion was h speaker mounting dimensio silhouettes. As a result, the of correlating data was divid so that each size unit will b dled by a single individual.

The following distributio established: 3½ in., R. C. Bie Permoflux; 4 in., S. Zuerker, in., J. Q. Tiedje, General I ment; 5¼ in., R. S. And Stromberg-Carlson; 6½ in., Holly, Radio Speakers; 7 in. Swift, Philco; 8 in. H. S. Kno Jensen Radio Mfg.; 4 × 6 in., Quam, Quam-Nichols; 5 × 7 i L. Marquis, Operadio Mfg.; 6 in. C. E. Hoekstra, Magnavox.

Dam Radio

UNDER THE TERMS of bids rece opened by the Federal Bureau Reclamation, shortwave r equipment for emergency and o ational communication is plan between remote, inaccessibl

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Are You Launching a New Product with LIMITED CAPITAL?

t the product, you've got the sales men and a sizeable piece of capital.

ou feel you've got to get a plant, and machinery, and set up a pro- e.

takes capital! And when you get o merchandising your product he trade and to the consumer, that going to be spread woefully thin.

"Divide and Conquer"

divide the job into "manufacture" tribution", and concentrate your capital and your manpower on one time. BUT reverse the usual pro- nd get going on the *distribution first.*

r product into the hands of dealers e public, without waiting to set up a of your own. That can come later, ood time.

portant thing is to get there with the rst. Get entrenched in distribution channels ahead of the other fellow in the mad scramble for that pent-up demand for consumer goods.

Let Lewyt be your factory

You can eliminate factory investment, inventory in materials and labor . . . and cut a sizeable chunk of time from your delivery schedule if you "Let Lewyt Do It".

You may find that we can actually save you money on the production. We are so accustomed to finding short cuts in tooling-up, economies in assembly methods, that getting a new job going in jig time and without lost motion comes natural.

Let us take over the production end . . and you concentrate your capital and your efforts on the distribution. It's a combination that can get you off to a head start in the consumer market on that new product of yours.

★ ★ ★

Write on your business stationery for 48-page book, "Let Lewyt Do It"—the story of the Lewyt organization in pictures. Lewyt Corporation, 62 Broadway, Brooklyn 11, N.Y.

Lewyt

FOR MORE THAN 50 YEARS A CONTRACT MANUFACTURER... EXPERTLY STAFFED TO PRODUCE COMPLETE ELECTRONIC AND MECHANICAL ASSEMBLIES, COMPONENT PARTS AND SUB-ASSEMBLIES, TO THE MOST EXACTING REQUIREMENTS

CONTINUE BUYING WAR BONDS

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TO ASSIST YOU WITH YOUR PROBLEMS OF

DESIGN
ENGINEERING
PRODUCTION

AS WELL AS THE MANUFACTURE OF ALL TYPES OF PARTS IN THE FIELDS OF

RADIO and ELECTRONICS

WE MANUFACTURE

Radio coils
- Solenoids
- Bank-wound
- Universal
- Universal progressive
- Paper section
- Layer-wound
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From the middle of the voice frequency to ultra-high frequency. Electronic and radio equipment of all kinds.

WE HAVE EQUIPMENT

FOR ANY TYPE OF TREATMENT:
- Hermetic
- Wax
- Varnish-impregnating
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We have a completely equipped laboratory with Q meters, twin-"T" bridges and special bridges . . . for frequency analyzing and prime standard of frequency.

ALSO

We are equipped for turning out special sub-assembly work . . . work on complete units where allied to our various facilities as well as small punch press work . . . lugging and terminal assembly . . . soldering, testing . . . original design and product design.

We invite you to consult with us without obligation.

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NOT INC.

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River irrigation
Idaho. Five rad
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Communication

RECENTLY PUBLISH
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Copies are availa
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Washington 25, D. C
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Capacitor Standa

FIXED CERAMIC-dielect
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NAB Activities

RECENT ANNOUNCEME
(National Association
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to its presidency of A
tice Justin Miller of
States Court of Appeal
J. Harold Ryan. Ryan
to the vice-presidency
managership of Fort I
Toledo, Ohio.

Other office holding
Frank M. Russell, NBC,
Stanton, CBS, as networ
and G. Richard Shafto,

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The New Model 400

ELECTRONIC MULTI-METER

A COMBINATION
VACUUM-TUBE VOLTMETER
AND
VOLT-OHM MILLIAMMETER
PLUS
CAPACITY
INDUCTANCE
REACTANCE
AND
DECIBEL
Measurements

Specifications:

D.C. ELECTRONIC VOLTS:
(At 11 Megohms input resistance)
0 to 3/15/30/75/150/300/750/1500/3000 Volts.

D.C. VOLTS:
(At 1,000 Ohms Per Volt)
0 to 3/15/30/75/150/300/750/1500/3000 Volts.

A.C. VOLTS:
(At 1,000 Ohms Per Volt)
0 to 3/15/30/75/150/300/750/1500/3000 Volts.

D.C. CURRENT:
0 to 3/15/30/75/150/300/750 Ma.—0 to 3/15 Amperes

RESISTANCE:
0 to 1,000/10,000/100,000 Ohms—
0 to 1/10/1,000 Megohms

CAPACITY: (In Mfd.)
.0005—.2 .05—20 .5—200

REACTANCE:
10 to 5M (Ohms) 100—50M (Ohms)
.01—5 (Megohms)

INDUCTANCE: (In Henries)
.035—14 .35—140 35—14,000

DECIBELS:
—10 to + 18 +10 to +38 +30 to +58

The Model 400 comes housed in a rugged crackle-finish steel cabinet complete with batteries, two sets of test leads, one set of V.T.V.M. probes and instructions. Size 5½"x9½"x10". Net.....

$52.50

SUPERIOR INSTRUMENTS COMPANY
DEPT. M., 227 FULTON STREET, NEW YORK 7, NEW YORK

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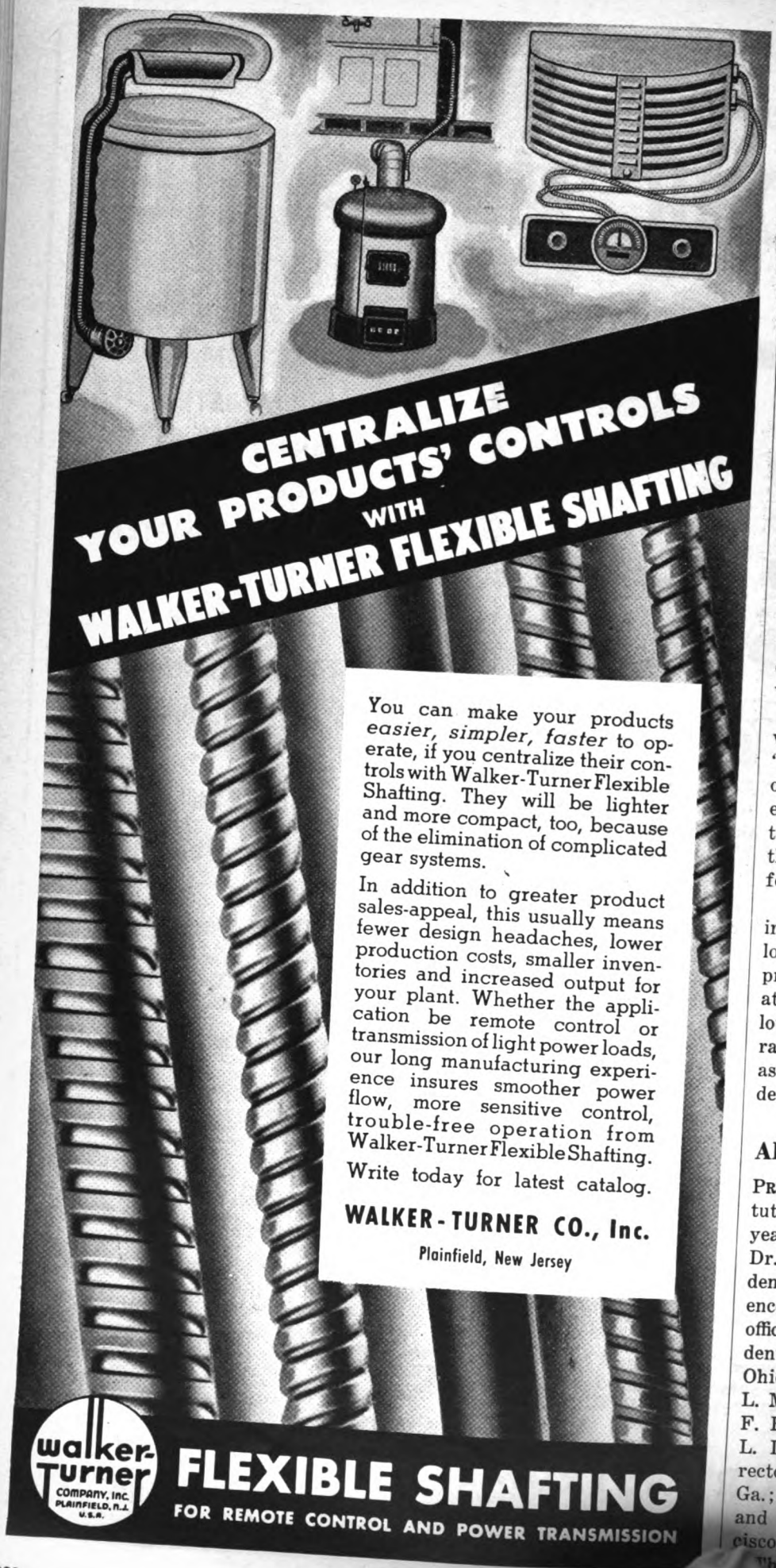

rector at large for medium
T. A. M. Craven, WOL, h
ously been elected as the
rector-at-large for medium
Directors at large for small
are Matthew H. Bonebrake
and Clair R. McCollough,
while J. Leonard Reinsch
and J. Harold Ryan, WW
serve as directors-at-large
stations for the one-year
ginning July 1.

Two amendments to the
have been approved, first t
the definition of large, sm
medium stations and se
broaden associate members

Loudness of Common

WORKING ON RESEARCH a
helping individuals with i
hearing, Dr. Harold Westlak
speech and hearing clinic at
western University discove
the word "strawberry" is t
easily heard of the commo
words tested.

Next in order of audibilit
volume are "chicken", "o
"grandmother" and "soldie
one hundredth word, whic
enough was "squeak", had
transmitted at nearly thre
the loudness of "strawber
fore it could be understood.

For the test, each word w
into a microphone, reproduce
loudspeaker in a separate
proof room. A pre-amplifi
attenuator controlled the r
loudness of the signal. These
ratings will be used, for one
as a standardized test of h
devices.

AIEE Officers

PRESIDENT OF THE American
tute of Electrical Engineers fo
year beginning August 1 19
Dr. William E. Wickenden, I
dent, Case School of Applied
ence, Cleveland, Ohio. Other
officers announced are: vice-p
dents—E. S. Fields, Cincin
Ohio; H. B. Wolf, Charlotte, N
L. M. Robertson, Denver, Colo.
F. Evenson, San Diego, Calif.
L. Lawton, Montreal, Canada,
rectors—J. M. Flanigen, Atla
Ga.; J. R. North, Jackson, M
and Walter C. Smith, San Fr
cisco, Calif.

The annual report of the In

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A Tribute

to all those who helped in the greatest scientific achievement of all time... the

ATOMIC BOMB

"TO KEEP THE PEACE"

For the inspiration and leadership displayed by the Executive, Military, and Naval authorities... to the Scientists... Engineers... to Labor, and to those Companies that played a part in this unprecedented achievement, General Cable voices the sentiment of America in extending highest praise and heart-felt appreciation. Because of their scientific genius, their untiring effort and their complete devotion to this gigantic task, Victory comes sooner and all mankind benefits.

General Cable Corporation is also justly proud of the contribution made by its own staff in the engineering development and manufacture of still secret and exceedingly special materials essential in the production of this device of war... and of Peace.

GENERAL CABLE CORPORATION

...RS OF BARE AND INSULATED WIRES AND CABLES FOR EVERY ELECTRICAL PURPOSE

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UNIONAIR'S manufacture of electrical assemblies to customers' specifications calls for the use of men with many specialized skills.

The photograph above shows precision hand workers laboriously and patiently building by hand the first working models of an electrical device. These models will be tested and approved before quantity production of the device is undertaken. Years of experience have proven to Unionair and its customers the wisdom of this step.

The time is fast growing closer when our organization will be able to turn from important war work to work for you. Write for our new booklet, titled, "Electrical Assemblies Made to Customers' Specifications," to: Union Aircraft Products Corp., 245 East 23rd Street, Dept. E, New York 10, N. Y.

UNIONAIR

Electrical Assemblies—Hydraulic Fittings
Duct Fittings—Junction Boxes

PRODUCTS CORP. NEW YORK

tute showed a total member 23,072, and revealed that dur year besides three national cal meetings there had been meetings held by local secti

Airborne Electronics

BASED ON THE ESTIMATES o liam A. Mara, the Bendix A Corp. staff executive in cha developments relating to th sonal airplane, there will be siderable market for radio other airborne electronic equi in the postwar period. Thi cast predicts there will be mum of 3,500,000 licensed p fliers by 1960. Pointing out this is a conservative estima declared that there would be of some 6,000,000 active or tial fliers in the nation at th of the war with a nucleus of 000 who have been trained airplanes. These consist of 327 private pilots holding licenses at the end of 1944; 2 licensed transport and comm pilots; 159,000 pilots liste trained by the AAF as of D ber 1944, and 47,000 pilots on the United States Navy as of December 1, 1944.

Including Scandinavia

AS A RESULT of special prio assistance granted by WPB t Norwegian government, the direct radiotelephone commu tion between Norway and United States is expected to for public use late this year. ilar aid has been given Franc

Census of Laboratories

NATIONAL RESEARCH Council busy compiling the 8th edition its directory "Industrial Resea Laboratories in the United Stat In the 7th edition, published 1940, there were 2,264 compan who listed their industrial resea laboratories, and the Council eager to receive information c cerning new laboratories whi may have been founded since th time.

Research men are urged to quire of their directors wheth questionnaires have been receiv as those reporting in 1940 will ha had their printed statements se

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NE VOLTAGE
CREMENTAL CONTROL

SORENSEN *Announces* THE INCREVOLT

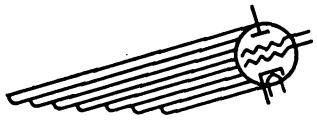
nsen and Company, Inc. offer a brand idea in variable A.C. voltage controls. The REVOLT is a control capable of providing 130 volts in increments as small as 1/10 variation.

current on Model 5 is 5 amps. maximum, 15 amps. maximum on Model 15.

outstanding control has the additional ure of "burn out" protection. The INCRE-LT is equipped with Klixon Thermostat tection, which provides absolute assurance nst short circuits or overloads, which in past caused many a burned out coil in the able voltage transformer.

Model 5
- 5 amps.
- 0-130 volts

Model 15
- 15 amps.
- 0-130 volts



S THE KNOW HOW THAT MAKES THE DIFFERENCE

SORENSEN & COMPANY, INC.

ORNE ELECTRONICS

STAMFORD, CONN.

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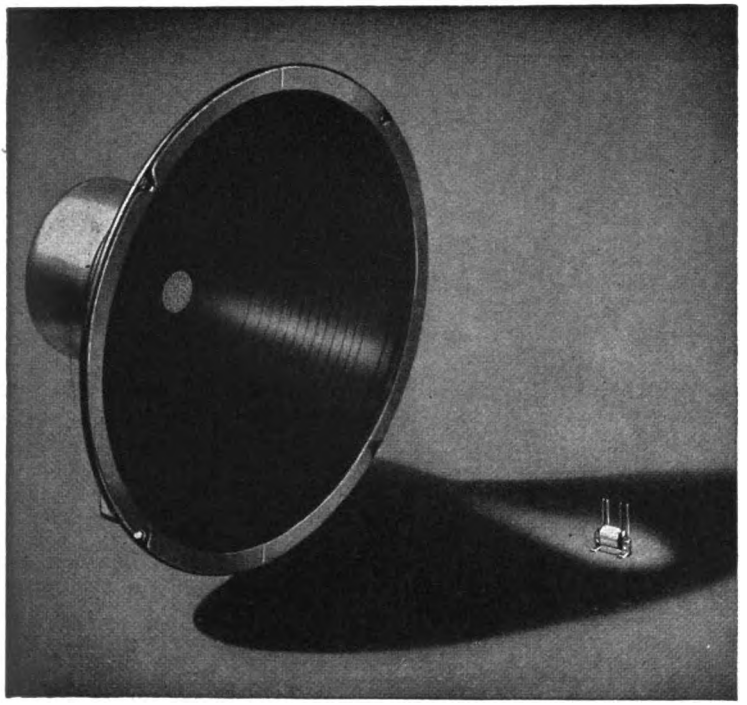

Permoflux Speakers and Transformers Set New Standards of Comparison!

New Permoflux speakers in a complete range of true-dimensioned sizes from 2" to 15", with power handling capacities from 1 to 20 watts, provide the finest sound reproduction for every application.

Permoflux midget transformers, with their many practical circuit applications, have literally revolutionized efficiency concepts where size and weight are determining factors.

Advanced engineering designs, improved manufacturing methods and new materials have all contributed their share in the development of Permoflux speakers, transformers, microphones and headphones. You can count on Permoflux to provide an acoustical unit to suit your exacting requirements.

BUY WAR BONDS FOR VICTORY!

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PIONEER MANUFACTURERS OF PERMANENT MAGNET DYNAMIC TRANSDUCERS

for revision. If no questionnaire has arrived, one will be sent upon request to the Library, National Research Council, 2101 Constitution Avenue, Washington 25, D. C. There is no charge nor obligation for inclusion in the listing.

Broader ASA

CHANGES HAVE BEEN made in the Constitution of the American Standards Association (ASA) which will remove restrictions confining its work to "those fields in which engineering methods apply". Thus, future standardization projects can be in any field which deserves national recognition. Other changes provide for specific mention of the consensus principle, by which all groups with an interest in a particular standard have the right to a voice in its development, and allow for election to the board of directors of three members-at-large. At present all but the ex-officio members of the board are nominated in rotation by the member bodies.

End of ABSIE

AT MIDNIGHT on July 4, the American Broadcasting Station in Europe (ABSIE) went off the air after fourteen months of continuous operation. Operated by OWI, the station developed a tremendous audience estimated at one time at 80 percent of the people of occupied Europe.

Berlin to America

AT THE BEGINNING of July, Press Wireless began direct radiotelegraph service between Berlin and the Times Square control center in New York. The first message was one addressed to American Broadcasting Co., New York, from one of its correspondents, and was received at 300 words per minute. Handled through the mobile station PX, transmission is later to be extended to voice and radiophoto services.

RCA Scholarships

PROMISING YOUNG scientific students are to be encouraged by a scholarship plan adopted by Radio Corp. of America and recently announced by Brigadier General

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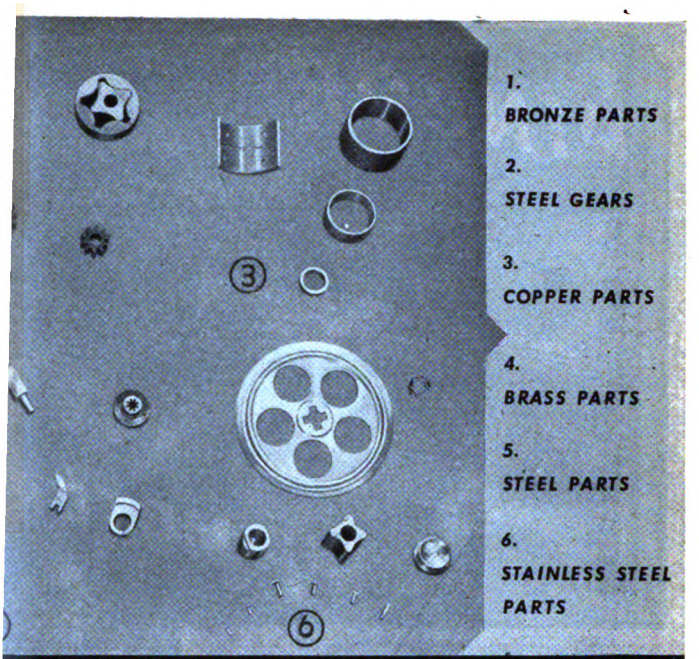

POWDER METALLURGY permits low cost, high volume production of close tolerance parts hitherto impossible by other methods. Other advantages include: maintaining high purity of metal content; obtaining a wide range of certain physical properties . . . with nominal material waste.

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FOR YOUR POSTWAR NEEDS... High "Q", high permeability (appr. 30) Iron Cores for use from 400 KC to 2000 KC. **RADACOR** Iron Cores are

RADACOR IRON CORES

also available in a wide variety of sizes, shapes and permeabilities for F.M. and television, in addition to our complete line of electronic cores.

ELECTRONIC & MECHANICAL POWDER METALLURGY

MICRO-FERROCART PRODUCTS DIVISION

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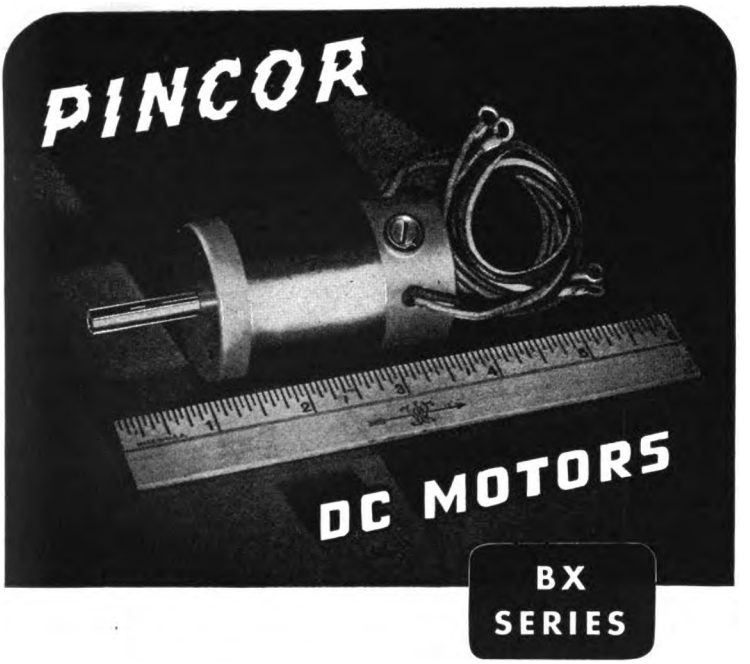

The urgent demand, in peacetime days, by the aircraft and radio industries for a compact, efficient D.C. motor was the challenge that led Pioneer to develop the Pincor BX series. Today Pincor BX motors flow from our plant in a steady stream to the producers of aircraft and radio equipment for the armed services.

Pincor BX motors, in their classification, meet the varied requirements of aircraft and radio manufacturers that demand light weight, compact motors for efficient and dependable application. Pincor BX motors are direct drive, ball bearing, high speed units wound for continuous or intermittent duty. Shunt, series or split series windings are for operation on 12 to 24 volt battery systems currently used and may be easily modified to meet your product demand.

Depend on these rugged Pincor quality-proven motors in the BX series. Send your problem to Pioneer engineers and let them put their years of experience to work for you. Consultation with these men will not obligate you in the least.

DYNAMOTORS • CONVERTERS
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BUY MORE BONDS!

David Sarnoff, the company's president.

The plan provides for ten students to receive awards during the academic year 1945-46, thirty during 1946-47, fifty during 1947-48, and sixty each academic year thereafter. Each consists of a cash award of $600.

Eligible students will be those enrolled at universities to be selected by the RCA education committee. Selection will be made upon recommendation of the dean and by approval of the committee, which consists of James Rowland Angell, president emeritus, Yale University and counselor of NBC (chairman); Gano Dunn, president, J. G. White Engineering Co., president of Cooper Union, and RCA director; C. B. Jolliffe, vice president in charge of RCA laboratories; and F. H. Kirkpatrick, director of education and training, RCA Victor Division.

Stratovision

A TRANSMISSION TECHNIQUE whereby vhf and uhf signals will be retransmitted from airplanes flying in the stratosphere is being planned on a cooperative basis by Westinghouse Electric Corp. and the Glenn L. Martin Co.

The radius of coverage of a television or f-m transmitter can be increased from about 50 miles for the terrestrial transmitter to about 200 miles by Stratovision, and the power required to cover the larger area by the stratosphere antenna reduced to about two percent of that required to cover the smaller area a number of terrestrial antennas.

Slow speed aircraft capable of maintaining their position against high altitude winds would circle above the area to be covered, receiving signals beamed up from small studio relay transmitters or relayed to them from other stratosphere stations. The programs would then be retransmitted to domestic ground receiving antennas.

The strato-station airplane would be controlled by an autopilot. The aircraft crew would need only make minor adjustments of the controls. The uhf directional relay antenna arrays would be kept focused on the circling aircraft by servo con-

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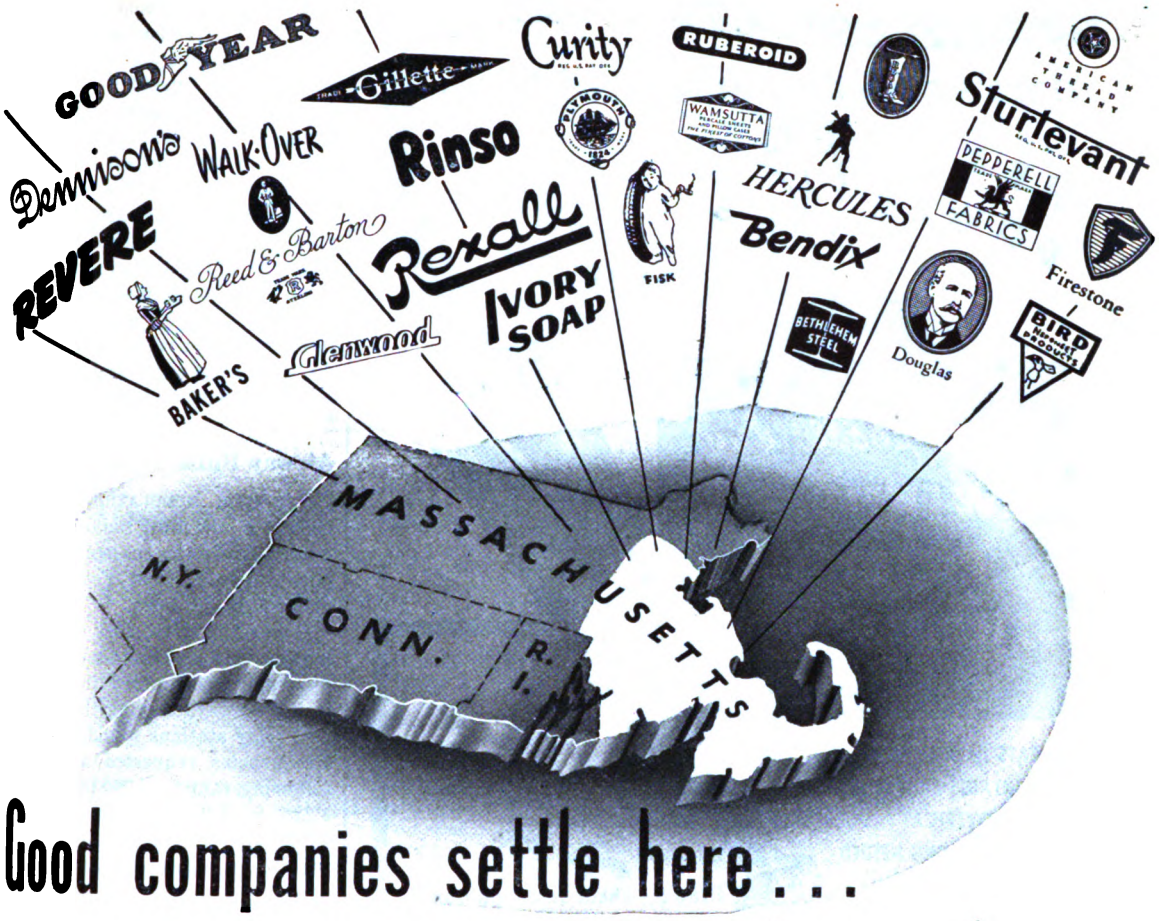

Good companies settle here . . .

Today, as always, Southern New England is the heart of the world's richest, most highly-concentrated market . . . the best of all reasons why industry should—and does—make this its home.

Draw a circle 500 miles from the center of Southern New England and you will include 58,000,000 consumers. Into that circle, Southern New England pours not only consumer goods but its producer commodities—machinery, tools, ball bearings—the parts and equipment that keep other industries going.

Beyond that circle looms the great world market of tomorrow . . . a market that will be served most efficiently by Southern New England's strategically located ports.

Southern New England has its personal appeal, too. For with its many delightful residential communities, its hills, lakes, and sandy beaches never more than a few miles from where you work, Southern New England is a great place to live and play.

and stay!

As you weigh the future of your new or expanding business, consider Southern New England.

Search where you will, you won't find a more favorable spot . . . *anywhere.*

For your business and personal postwar planning, we offer an industrial booklet in full color: "Southern New England for Tomorrow's Industry". This booklet is yours for the asking. Write to P. E. Benjamin, Manager of Industrial Development, The New Haven Railroad, 80 Federal Street, Boston 10, Mass.

This is one of a series of advertisements presenting the industrial advantages of Southern New England.

THE NEW HAVEN R.R.

Serving **SOUTHERN NEW ENGLAND** *with a network of rail and highway transportation that puts every manufacturer* ON THE MAIN LINE.

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trollers. There would be channels for four television and five f-m stations to operate through the Stratovision installation. Power for the radio equipment would be about four percent of the motive power for the airplane.

Because one airplane installation will cover so large an area, the operational cost of Stratovision will be one-thirteenth that of land based relay and transmission stations. Technical aspects have been solved in connection with other activities. As soon as production is available tests will be conducted.

Airway Pulse-Time Relay

PULSE-TIME MODULATION is to be used in a new u-h-f radio relay system which is the subject of an application to FCC by Federal Telephone & Radio Corp.

Connecting New York and Washington, this system would be used to supply coordinated information to the airways serving these cities. Ten relay stations would intervene. Frequencies requested are in the following ranges: 4,200 to 5,200 Mc, 1,225 to 1,325 Mc, and 7,000 to 8,500 Mc, with A2, A3, A4, A5 and special emission and 10 watts of power.

Safety Engineering Joins the Curriculum

NEW YORK UNIVERSITY has been given a grant of $8,000 by The National Safety Council to permit installation of safety engineering courses in the College of Engineering as an integral part of basic engineering training. A professorship will be established and all engineering laboratories and shops will be reorganized and reequipped so that they will incorporate true safety practices. Safety will not be offered as a specific course but will be integrated into all other courses of the school. The slogan will be "to make the embryo engineer unconsciously safety conscious."

Industrial Electronic Training Course

LECTURE MATERIAL consisting of sound-slide films, each approximately one-half hour long, review booklets with questions, and an in-

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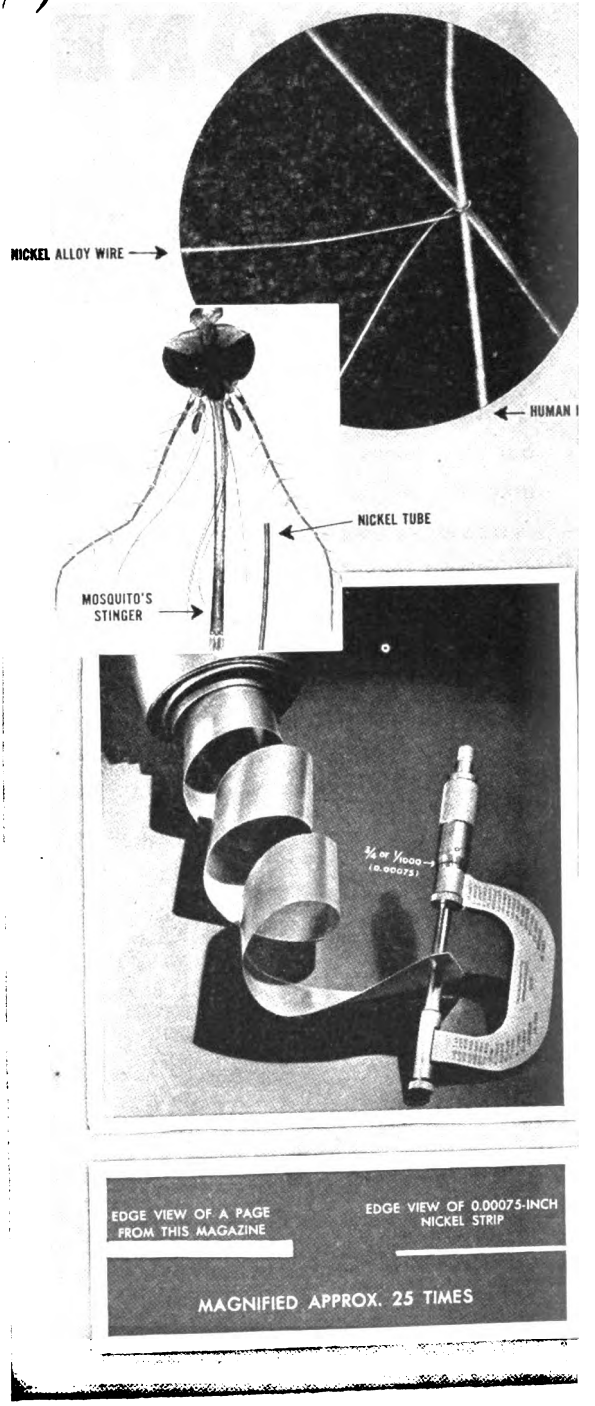
Wire Sizes



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IT CAN'T BE DONE!

Time and again this war has proved that *nothing is impossible!* Proved right here in our own backyard, as Temple engineers and craftsmen delve along unblazed trails of research and experiment to design and *produce* more and better communications equipment for the battle fronts.

This ability to both design and deliver the seemingly impossible, under stress of war, has bred an unfailing inventive capacity that should prove invaluable in meeting the vast commercial requirements of peace.

Temple

Electronics Division

TEMPLETONE

RADIO MFG. CORP.

New London, Conn.

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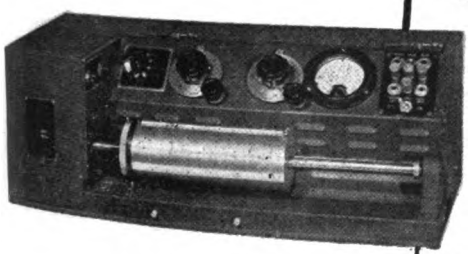
1935
FACSIMILE COMMUNICATIONS
1945

Since 1935, the engineering staff of Times Telephoto Equipment Inc. and its predecessor company has been engaged exclusively in developing and producing facsimile communications equipment.

Times Telephoto's long experience in this new and revolutionary field of communications, its leadership in design and practical application, will be invaluable to the postwar user. These facsimile sets are used for sending and receiving written and printed matter, photographs and maps. They are standard equipment of the U.S. Signal Corps, Army Air Forces, Navy, the Office of War Information and some commercial companies and foreign governments.

When all military needs have been met, Times Telephoto Equipment Inc. will be ready to supply facsimile communications equipment especially designed to meet your particular requirements. Write today for your copy of the booklet, "Elements of Facsimile Communications."



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A Subsidiary of The New York Times

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Unusual and Vital
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PRODUCED BY
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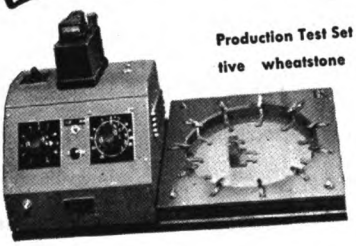
SUBCONTRACTING DEPT.

Special Short Wave Transmitter Range: 1-16 megacycles on one dial.

Development of special hearing aid analyzer for Western Electric Company.



Production Test Set to test varisters. A sensitive wheatstone bridge arranged with switching means for quickly checking a number of varisters in rapid sequence.

Manufacturers have continually called upon the modern facilities of Tech Lab Subcontracting Department to assist them in the production of unusual and vital electronic equipment. Our Engineering Department is ready to assist you with your production problems.

Carbon filling machines for precision filling of carbon microphones.

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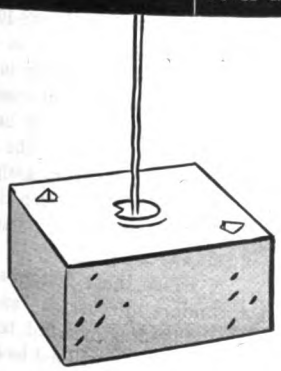
MEASURE HIM CAREFULLY...

ITEM		GOOD COMMERCIAL TOLERANCE
CAST DIMENSIONS	LESS THAN 1"	± 1/64"
	1"-4"	± 1/32"
FINISH GROUND DIMENSIONS (PLANE SURFACES)		±.005"
PARALLELISM BETWEEN GROUND PARALLEL FACES		.002"/LINEAR INCH ACROSS FACE
PERPENDICULARITY	BETWEEN GROUND FACE AND CENTER PLANE OF "AS CAST" MAGNET.	1/2°
	BETWEEN TWO GROUND FACES.	1/2°
CASTING DRAFT		1°
GRINDING ALLOWANCE		RULE: .015"/1.5 SQUARE INCHES OF EACH SURFACE TO BE GROUND.



He's no Beau Brummell, this rough and ready permanent magnet but when he's measured up for casting, he's just as fussy about the length and girth of his trousers and about the fit of the coat Give him a suit that's too baggy or skin-tight and he won't be able to do his best work.

Casting tolerances for the ALNICOS are important to know when designing permanent magnets. Certain latitude is permissible but to stray beyond practical limits is to invite trouble. Many years of experience in designing and casting ALNICO Magnets have taught us much about casting tolerances. Our ideas are summarized in the chart shown at the left and discussed in detail in our pamphlet PERMANENT MAGNET DESIGN. If you are designing your own magnets you should have this information handy. We'll be glad to send you a copy.

9-CC-1

CINAUDAGRAPH CORPORATION

2 SELLECK STREET STAMFORD, CONNECTICUT

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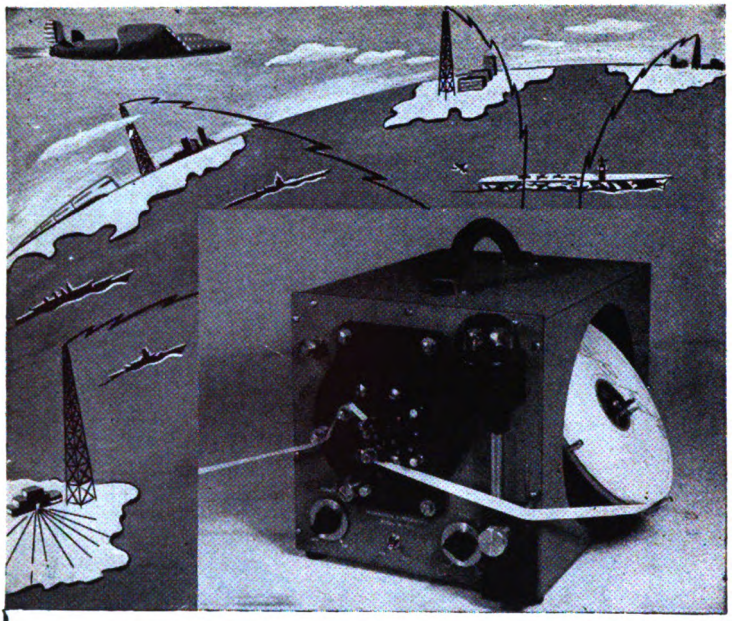

1200 WORDS *per minute!*

Extraordinary — but true! Mecanitron has made new history in communications! This proven performance recorder equipped for either on-off keying or frequency shift reception may be used alone for code transcription at any speed or in connection with teletype transmitting and receiving terminal equipment for translation into the printed word.

Constructed for all speeds; because of its clear, accurate reception at 1200 w.p.m., Mecanitron does a superb job at ordinary and low speeds.

Pulse amplifier output response constant when input power varies between —5 db to +25 db; input impedance 500 ohms; operating voltage ranges 110-120 volts A.C. at 50-60 cycles, 220 volts A.C. at 25-50-60 cycles.

For further details, write to

MECANITRON CORPORATION

711 Boylston St., Boston 16, Mass., U.S.A.

hermetically sealed and other tra formers and reactors, oil-impr nated power factor and mol bakelite capacitors, and wire-wo resistors. These changes w provided in an amendment to P orities Regulation 13. Also, number of restricted radio a radar tubes was changed by t removal of four tubes from the li and the addition of seven, making total of 23.

EDUCATIONAL BROADCASTS. Und the auspices of FCC, a three-d meeting was recently held in Was ington by educators representi schools throughout the countr The objective was to plan wit SPB (Surplus Property Board) t utilization of surplus radio a electronic equipment in fosteri and expanding educational pr grams. The gathering envisione an ultimate system of more tha 800 broadcasting stations devote exclusively to educational pursuit Other factors considered were t possibility of using surplus equip ment and components for study i classroom and laboratory as well.

FCC REGULATIONS. Section 6.11 o the FCC rules governing fixed pu lic radio service has been amende to permit use of A-3 emission fo the following purposes: transmi sion of addressed program mat rial, as set forth in section 6.5 controlling the transmission and re ception of addressed program mat rial, and controlling the transmi sion and reception of facsimile ma terial. Changes have also bee made in the requirements for peri odical reports of frequencies use and points serviced.

INTERIM F-M. Until the time when receivers for the 88-106 mc band are available, FCC is encouragin temporary operation in both bands Accordingly, any licensee wishing t operate in the new band may in formally apply to the Commission for the temporary assignment of a frequency until such time as rules, regulations and standards ar finally adopted.

Since these factors are currently under discussion and may be changed or modified, temporary authorization will not be a determination of coverage, power, or other factors relating to the assignment that existing stations will eventually be given. Requests for tem-

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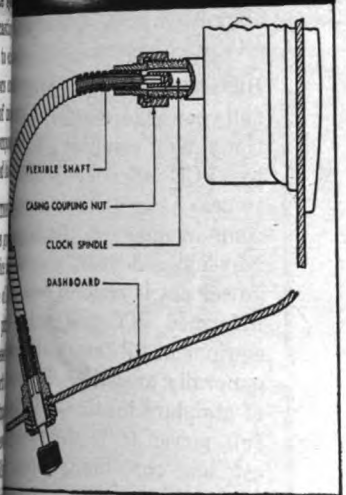
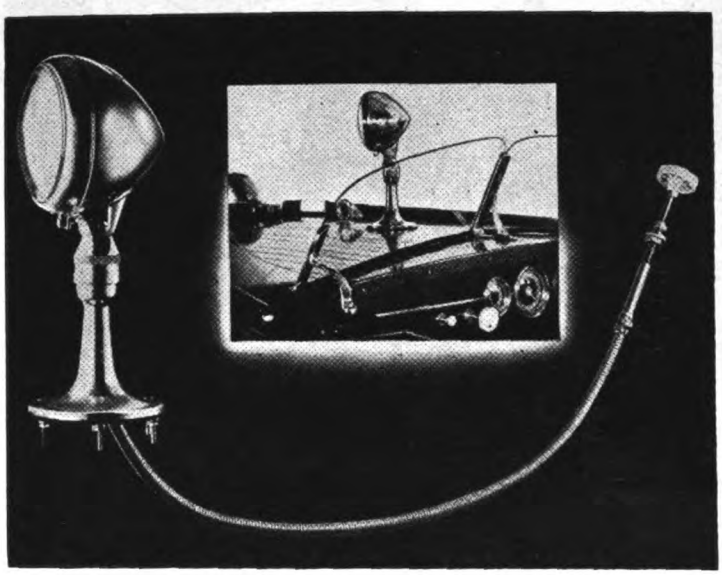
...e's a simple way to provide ...BINED PUSH-PULL AND ROTATIONAL REMOTE CONTROL



This Automobile Clock is set by pushing in the clock spindle to disengage it from the mechanism and then turning. The sketch shows how both the push-pull and rotation are obtained with a flexible shaft from a convenient point under the dash. A similar arrangement is used on speedometers for resetting trip mileage.

Remote control of elements requiring push-pull as well as rotation, can readily be accomplished with a single S. S. White Remote Control Flexible Shaft. Two examples are illustrated. Designers of electronic equipment may find occasion to use this simple solution to the problem of combined push-pull and rotational remote control.



This Marine Spot Light is rotated horizontally by turning the control knob of the flexible shaft remote control, and is tilted up by pulling the knob out, and tilted down by pushing it in. A similar arrangement is used on automobile spot lights.

Send for This 256-Page Flexible Shaft Handbook

This book fully covers the subject of flexible shafts. It gives all essential engineering data on both power drive and remote control shafts and explains how to select and apply them for specific requirements. A complimentary copy will be mailed if you will write for it on your business letterhead and indicate your position.

ARMY E NAVY

S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. E, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS — AIRCRAFT ACCESSORIES
MOLDED PLASTICS
MOLDED RESISTORS — FLEXIBLE SHAFT TOOLS

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GET
THIS VALUABLE BOOK
On Temperature Control

Mailed to you without obligation immediately

TO AIRCRAFT DEVELOPMENT ENGINEERS

Before deciding on temperature regulating devices for your products, be sure to investigate Fenwal Thermoswitches. They operate on an unusual principle, and offer many advantages not found in other types of switches. The Fenwal Engineering Data Book contains detailed drawings of construction of various models and typical installations.

- Compact construction permits installation in tight places.
- Make and break unaffected by external vibration.
- Readily adjustable for wide range of temperature control.
- Minutely accurate.
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- Inexpensive.

A 44-page treatise on Thermal Control including installation drawings, photographs, blueprints and descriptive suggestions for future planning with basic principles involved in temperature regulation and control. . . . Just write for your *free* copy on your business letterhead.

"IF IT'S A FENWAL — IT'S THE BEST OF ALL"

THERMOSWITCHES
Fenwal, Inc.
FOR COMPLETE TEMPERATURE CONTROL
Pleasant Street, Ashland, Massachusetts

porary operation of this type should include a description of the proposed transmitting equipment, output power, antenna system, and monitoring equipment or methods. Special authorizations will be issued for 90-day periods by the chief engineer.

The Commission also points out that the 42-50 mc band will be closed as soon as f-m receivers are generally available to cover 88-106 mc. This will make it unnecessary to build new receivers covering the 42-50 mc region. However, because it will not be necessary for an existing f-m licensee to give up a frequency in the 44-50 mc band until a television station is authorized to operate in it, it is considered likely that few f-m stations will find it necessary to make an interim move to the 42-44 mc band suggested in the Commission's final allocation report.

BROADCAST POWER. After Sept. 1, full power operation will be optional as a result of a recent order by FCC affecting broadcast stations. After October 1 it will become mandatory. Dating back to November 6 1942, the one-decibel power cut is restored because WPB informed FCC that materials and equipment for transmitters are now generally available. The operation of standard broadcast stations with full power is in the public interest, and opportunity should be afforded for making the necessary readjustments and tests to return to normal operating practices.

Also, since materials and equipment are now available to a-m stations for construction of most facilities required by FCC's standard of good engineering practice, FCC will require that licensees who have been permitted to operate without fully conforming to standards because of the scarcity of materials must now make application for the necessary improvements.

BUSINESS NEWS

PACKARD-BELL CO. is expanding into the E. L. Cord Building at 3443 Wilshire Blvd., Los Angeles, Calif. Simultaneously, the company's engineering department will include a research division.

SONORA RADIO & TELEVISION CORP., Chicago, Ill., acquires the Sterling Wood Manufacturing Co. to pro-

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more efficient ...in miniature

ACTUAL SIZE

To clean and generally maintain the bulky, smelly oil lamp was a daily chore. In contrast, the compact incandescent lamp that gives many times the light, requires no maintenance except a rare and easily installed replacement. Its operation is safe and simple.

Just as the incandescent lamp opened up new avenues for more efficient lighting, so the miniature electronic tube presents new possibilities in the science of electronics. More compact sets—greater durability because of small rugged parts and better performance when used in high frequency circuits, are advantages of using Tung-Sol Miniature Tubes.

Manufacturers of radio sets and other electronic devices are invited to study the advisability of using miniatures in their new equipment. Tung-Sol Engineers would be glad to aid them in designing circuits and selecting tubes. All plans that are disclosed in consultation are held in strictest confidence.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors

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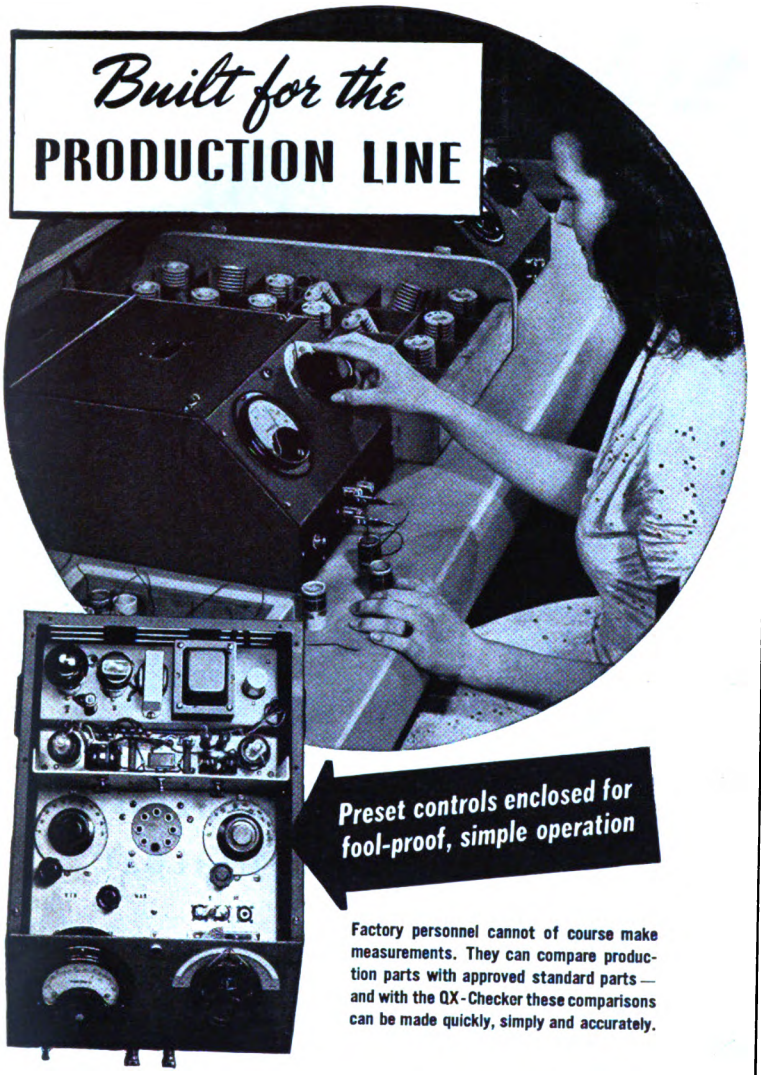

Factory personnel cannot of course make measurements. They can compare production parts with approved standard parts — and with the QX-Checker these comparisons can be made quickly, simply and accurately.

QX-CHECKER *TYPE 110-A*

The QX-Checker is specifically designed for production use to check both the reactance and resistance of any R.F. component. These properties are simultaneously indicated when a component is resonated in a tuned circuit. The two factors, reactance and resistance, are separately indicated, one on the condenser dial, the other on the meter so that the deviation of either from established tolerances is immediately shown. Insures uniform parts held within close tolerances. Frequency range 100 kc. to 25 mc.

For further information, write for catalog "C"

BOONTON RADIO Corporation
BOONTON, N. J.

DESIGNERS AND MANUFACTURERS OF THE "Q" METER . . . QX-CHECKER . . . FREQUENCY MODULATED SIGNAL GENERATOR . . . BEAT FREQUENCY GENERATOR . . . AND OTHER DIRECT READING TEST INSTRUMENTS

duce radio cabinets, the Rek-Plastik Co. to manufacture phonograph records, and the Electronic Parts Mfg. Co. to produce scarce components.

CROSLEY CORP., including station WLW in Cincinnati and other broadcast facilities, has been sold to Aviation Corp.

WIRE RECORDER DEVELOPMENT CORP. is expanding into larger space in the Field Building, 135 South La Salle St., Chicago, Ill. The new quarters will contain a studio for demonstration work.

WESTINGHOUSE ELECTRIC CORP., Pittsburgh, Pa. has just made its largest ($3,063) production-suggestion award to a retired real estate operator working in the Bloomfield plant. The suggestion has reduced by 62 percent the quantity of gold alloy wire required to solder electronic tube parts.

AIREON MFG. CORP. has purchased and equipped a special railroad car

to be used in the demonstration, test, and installation of their railroad radiotelephones.

RADIO CORP. OF AMERICA has concluded a new agreement with N. V. Philips' Gloeilampenfabrieken of Eindhoven, Holland, to permit continuation of licensing other manufacturers under the latter company's U. S. patents.

MAGUIRE INDUSTRIES, INC. merges the Ferrocart Corp. and Micro Products Corp. into a new powder metallurgy division. Both operations have been moved to 375 Fairfield Ave., Stamford, Conn.

REEVES-ELY LABORATORIES, New York, N. Y., has consolidated its

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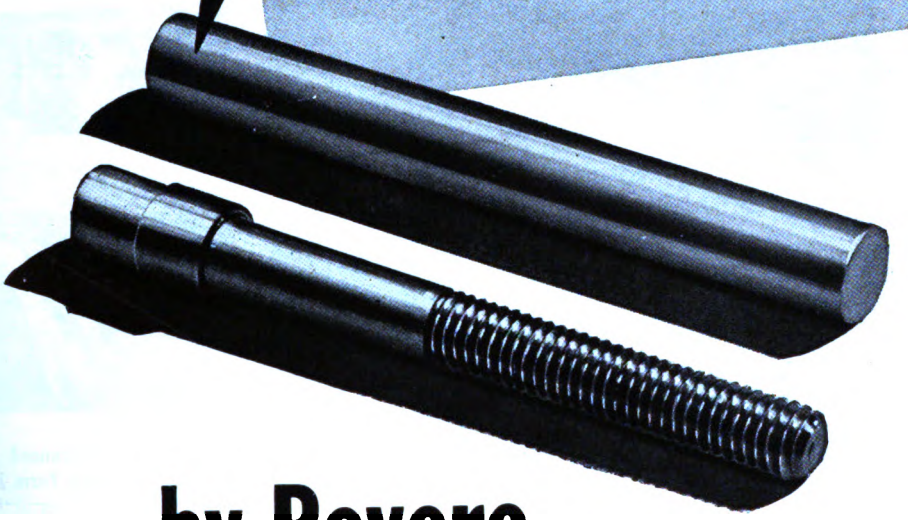
New! Free-Cutting Copper Rod



...by Revere
increases electronic production

To meet the demands of the electronic and electrical industries, Revere now offers Revere Free-Cutting Copper Rod.

This is oxygen-free, high conductivity copper containing a small amount of tellurium. This, plus special processing in the Revere mills, greatly increases the speed with which the metal can be machined, makes it possible to hold closer tolerances, improves the finish of completed parts, lessens rejects, cuts costs.

Revere Free-Cutting Copper Rod already has proved invaluable for the precision manufacture of certain interior vacuum tube parts that must be made to exceptional standards. However, it does not make a vacuum-tight seal with glass, and OFHC copper or other metals and alloys must continue to be used for that purpose. The rod is available in sizes up to 2" and in all the usual shapes.

The Revere Technical Advisory Service has worked out solutions of a number of difficulties encountered with the use of copper and its alloys in electronics. May we collaborate on your problems?

Listen to The Human Adventure *on the Mutual Network every Wednesday evening, 10 to 10:30 p.m., EWT*

CUSTOMERS REPORT:

"This material seems to machine much better than our previous hard copper bar; it cuts off smoothly, takes a very nice thread, and does not clog the die." (Electrical parts.)

"Increased feed from 1½" to 6" per minute and do five at one time instead of two." (Switch parts.)

"Spindle speed increased from 924 to 1161 RPM and feed from .0065" to .0105" per spindle revolution. This resulted in a decrease in the time required to produce the part from .0063 hours to .0036 hours. Material was capable of faster machine speeds but machine was turning over at its maximum. Chips cleared tools freely, operator did not have to remove by hand." (Disconnect studs.)

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Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.; New Bedford, Mass.; Rome, N. Y. — Sales Offices in principal cities, distributors everywhere

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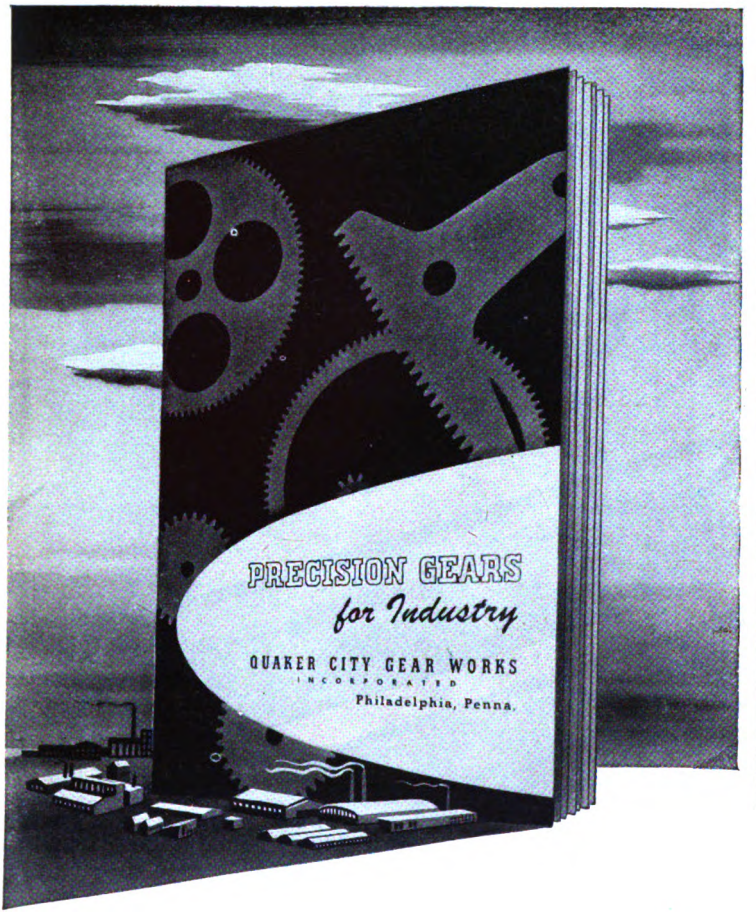

Yours for the asking

A new informative booklet on gears. It has illustrated sections on practically every known form of gearing, together with many reference tables and formulas. Write for your copy today on your company stationery.

Quaker City Gear Works
INCORPORATED

1910 N. Front Street, Philadelphia 22, Pa.

various subsidiary companies and operating divisions. Now housed in 15 buildings in three states are Reeves Sound Laboratories, Hudson American Corp., American Transformer Co., Winsted Hardware Mfg. Co., and Waring Products Corp.

GENERAL ELECTRIC Co. has demonstrated a model of their postwar large-screen television receiver, giving a 16 × 22 in. picture. Shown at the same time was a new combination radio-phonograph incor-

porating an advanced design but still in tentative form because improvements are expected. In the accompanying illustration, the television receiver is shown delivering a special WNBT program put on for the purpose.

HALLICRAFTERS Co., Chicago, Ill., hopes, with the assistance of spot authorization, to manufacture 250,000 f-m converters, permitting reception on prewar f-m receivers of transmissions in the new 88-106 mc band.

BENDIX AVIATION CORP. establishes a separate engineering and sales organization to coordinate development, manufacture, and marketing of low-cost radio communications and avigation equipment for personal airplanes. It comes under the Bendix Radio Division.

FRANK H. MCINTOSH, consulting radio engineer, is now located at 710 Fourteenth St., N.W., Washington 5, D. C.

PERMOFLUX CORP. has enlarged its manufacturing headquarters in Chicago to provide increased space

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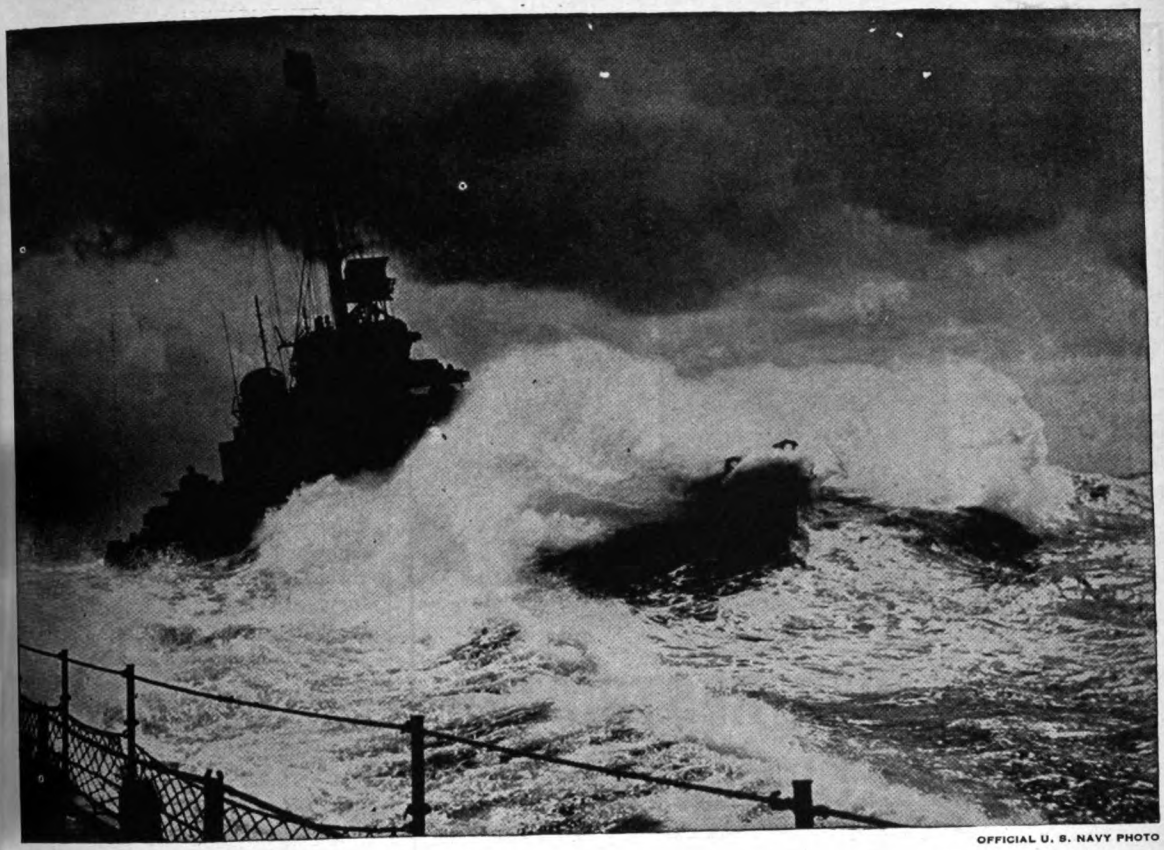

OFFICIAL U. S. NAVY PHOTO

Any port in a storm ... but there are no ports

More than one sailor has said, "It's a helluva place to fight a war!"

That's a miracle of understatement when you know the Pacific as well as the U. S. Navy knows it.

They know how many thousands of miles you have to go before you reach the fighting fronts.

They know there's almost continual rain and bad weather to hamper operations after you get there.

And they know there are no good ports!

Think of the thousands of ships, and the millions of tons of supplies it takes to keep our fighting forces moving toward Japan.

Imagine, if you can, the problem of handling those ships and supplies with no port facilities.

There are no giant cargo cranes... no miles of docks and warehouses...nothing but beaches, and human backs, and a refusal to call any job impossible.

Remember, too:

It takes 3 ships to do the supply job in the Pacific that 1 ship can do in the Atlantic.

It takes 6 to 11 tons of supplies to put a man on the Pacific battleline, and another ton per month to keep him supplied.

It takes a supply vessel, under ideal conditions, half a year to make one round trip.

Add up those facts, multiply by the number of sailors, soldiers, and marines for whom the Navy is responsible.

Maybe you'll begin to realize what "no ports" can mean in the rough, tough waters of the Pacific.

Maybe you'll see that we have *two* reasons to be proud of the U. S. Navy. *First*, the way they've sunk the enemy's ships.

Second, the way they sail *your* ships ... taking the worst the Pacific can hand them... but keeping the supply lines open ...keeping the attack *on schedule!*

SPERRY GYROSCOPE COMPANY, INC. GREAT NECK, N. Y.

★

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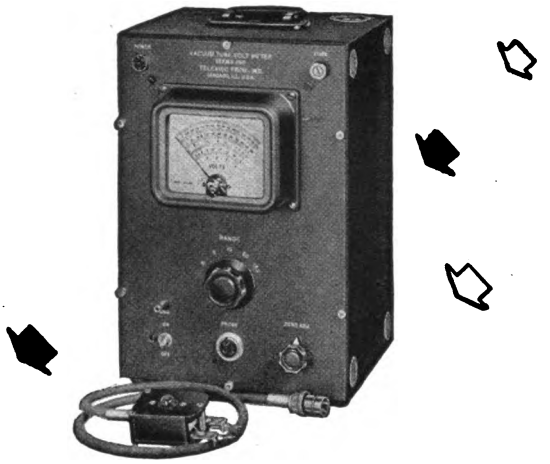
HIGHLY ACCURATE, STABLE VT VOLTMETER



features WAR RESTRICTED DEVELOPMENTS!

TELEVISO, pioneering in the production of measuring apparatus for the SONIC to UHF SPECTRUM, has specialized in building dependable Vacuum Tube Voltmeters.

A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable. IMPORTANT WAR TIME DEVELOPMENTS ARE AVAILABLE FOR THE FIRST TIME IN THE FOLLOWING FEATURES:—

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural.); sub-chassis is ⅛" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.

ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shortening of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usuable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the fi ld. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts ac. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago.

Televiso Products Inc.

7466 IRVING PARK ROAD CHICAGO 34, ILLINOIS

for production, engineering, and research.

DEMUTH GLASS WORKS INC., Brooklyn, N. Y., has been taken over by Foster-Forbes Glass Co., Marion, Ind. The company manufactures electron tube envelopes, besides other glass products.

TOTH & LORBER is the name of a new firm of engineering consultants consisting of Albert F. Toth and John F. Lorber and located at 38 Park Row, New York 7, N. Y. Specialties will include industrial electronics, communication, television, radio, and acoustics.

UNION PACIFIC RAILROAD has started electronic classes for company electricians in five cities through the road's 11-state territory. In many cases instruction is handled by Marquette-University-trained union leaders.

GENERAL TELEVISION & RADIO CORP., Chicago, Ill., has purchased the building at 2701 Lehmann St. formerly occupied by Press Wireless. A one-story structure with over 30,000 sq ft of space, it will house the factory and executive offices.

PERSONNEL

ARTHUR J. SANIAL becomes chief engineer of Atlas Sound Corp., Brooklyn, N. Y. He comes from the sound systems department of the Fox Film Corp.

ROYAL V. HOWARD, back from overseas duty with the U. S. Army, becomes vice-president in charge of engineering for Associated Broadcasters Inc. and the Universal Broadcasting Co. of San Francisco, Calif.

CHRISTIAN A. VOLF becomes director of research in the electronic and acoustic division of Robinson-Houchin Optical Co., Columbus, Ohio.

O. S. DUFFENDACK, director of research, North American Phillips Co., New York, N. Y., is appointed vice president and director of research and engineering.

GLENN E. WEBSTER goes from engineering supervisor in the Chicago office of NBC to join the engineering staff of Collins Radio Co. Cedar Rapids, Iowa. He will be in

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Boost radio sales with

built-in Telechron Selectors

HERE'S a double-duty timer to give your radio receivers the *extra* appeal needed for successful post-war selling. It's *much more* than an absolutely accurate electric clock. It turns on the set automatically at any pre-selected time in the morning to waken the owner with music. It switches the set on for favorite programs during the day and evening—then shuts it off at bedtime.

The cost to set makers is remarkably small — less than $4. Installation expense is low, too. Volume producers are already choosing it for moderate-price sets.

Radio listeners will like the Telechron Selector's easy finger-tip control. There are no knobs to turn and no difficult calculations. Programs are selected for any 15-minute period by flipping out one of the 48 keys around the large, legible clock dial. Keys are automatically reset to "off" position after timing periods are passed. Programs can be selected 10 hours in advance.

The C-28 Telechron Selector is only one of the full line of automatic timing and control devices we can supply for the sets you're now building or planning. *All use famed Telechron movements and self-starting synchronous motors for accuracy, dependability and long life.*

For full information about the C-28 Selector and other Telechron timers, wire or write Automatic Control Division, Dept. K.

Telechron

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Available NOW!

VHF RECEIVER KIT with New FM Band

88.6 to 107.6 Mc

115 to 140 Mc

ACORN TUBES • SEPARATE TUNING UNIT

Ideal for Communications Work, Instruction, Training, etc.

A unique 10 tube Concord Kit for FM-AM and VHF reception with a separate tuning unit employing the new acorn tubes. Circuit design is straightforward and simple with no frills or unnecessary components. Extremely compact, sturdy and easily assembled. Has only two controls on the front panel—the tuning control and the volume control. There's a standard headphone jack for output, a switch for changeover from FM to AM, and a power switch in the AC line.

Comes complete with all necessary parts including holes punched and all tubes, wire, solder, hardware, and detailed instructions. Chassis is 10" x 12" x 3" black finish. Dull black panel is 6¼ x 12" wide. Two models—CRC-130—Range 88.6 to 107.6 Mc (for the new FM Band), and CRC-140—Range 115 to 140 Mc. Quantity limited—while they last —Use coupon below to order today or to ask for literature giving detailed information and specifications.

Complete with Tubes **$54.95**

CONCORD RADIO CORP.

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CONCORD RADIO CORP.
901 W. Jackson Blvd., Dept. G-95, Chicago 7, Ill.

Please ship at once the Concord VHF Receiver Kit—or special descriptive literature—as checked below.

☐ CRC-130—VHF Kit Range 88.6 to 107.6 Mc ☐ CRC-140—VHF Kit Range 115 to 140 Mc ☐ Send literature giving details and specifications

Name.....

Address.....

City.....*State*.....

charge of development in broadcast speech input and associated equipment.

P. B. HARWOOD is elected vice-president in charge of engineering of Cutler-Hammer, Milwaukee, Wis.

ROBERT W. CLARK, former WEAF station engineer, becomes television operations supervisor at NBC New York, N. Y.

JEAN M. ROBERTS, formerly senior research and development engineer at Lear, Inc., becomes chief engineer of Associated Electronics Corp., New York, N. Y.

E. H. SCOTT, founder and president of the company, resigns as head of E. H. Scott Radio Laboratories, Chicago, Ill.

RAY ELLIS, FEA consultant and former director of the WPB Radio-Radar Division, is chairman of a governmental committee studying German electronics. Other members include Ralph Bown, Bell Laboratories; present Radio-Radar Division Director, L. J. Chatten; Captain F. C. Layne of the Navy Electronics Division; Captain Gilbert Myers, USN, Secretary of Joint Communications Board; and Brigadier General T. C. Rives, deputy Air Communications Officer, AAF Hq.

JENNINGS B. DOW, director of the Electronics Division in the Navy

Bureau of Ships, has been promoted from Captain to Commodore.

GARRARD MOUNTJOY, who has been in charge of research and development in the Radio Division of Lear Inc., has been advanced to take charge of all research and development in the New York laboratories.

F. F. SYLVESTER becomes technical director of Reeves-Ely Laboratories. Previously with Lewyt Corp., he will be in charge of research and engineering.

JOHN T. TATE, division chief, Na-

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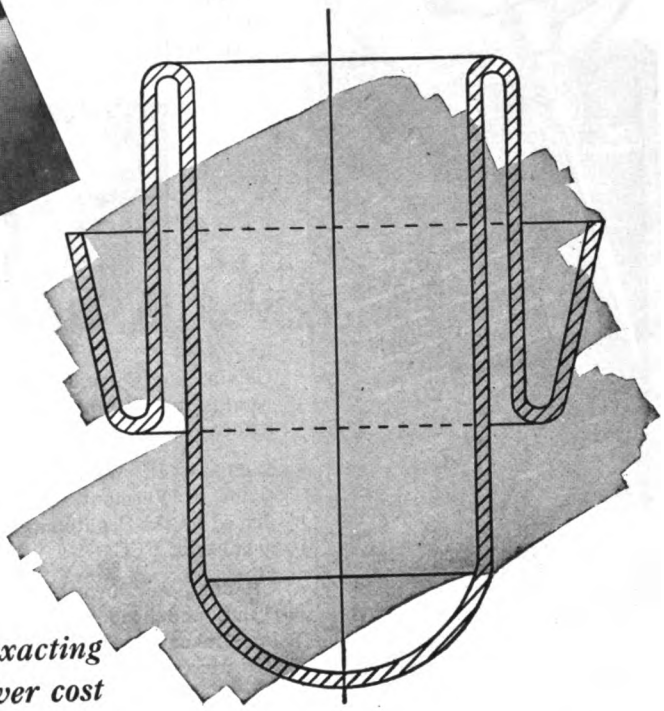
SCOVILL DEVISED A NEW SCHEDULE FOR TRANSMITTER TUBE ANODES

. . . and put them on the air faster



How Scovill Electronents meet exacting specifications . . . often at lower cost*

This anode for a radio broadcasting tube involved several difficult problems. Specifications called for a seamless, one-piece, pure oxygen-free copper shell . . . free from imperfections. Dimensions: length 6 41/64", I.D. 3", diameter across hollow flanged section 5 61/64", average wall thickness .090". That hollow flanged section was no cinch. But an ingenious metal-working schedule took care of that. Specifications were met 100% . . . and costs were surprisingly low.

Whether your electronic equipment requires small components or large assemblies, you, too, can save time, trouble and money by calling on Scovill's design ingenuity and versatility in all metals and all metal-working techniques. To learn why Scovill is in a position to give you impartial advice about whether to forge, draw, stamp or machine your Electronents*, send for literature. Fill in the coupon below and mail it today.

*Electronents = Electronic Components

Scovill
MANUFACTURING COMPANY
WATERBURY 91, CONN.

Please send me a free copy of "Masters of Metal" booklet describing your facilities. I am interested in the ELECTRONENT* applications checked.

- ☐ Batteries
- ☐ Record Changers
- ☐ Clips
- ☐ Condensers
- ☐ Dials
- ☐ Escutcheons
- ☐ Jacks
- ☐ Lugs
- ☐ Panels
- ☐ Sockets
- ☐ Stampings (misc.)
- ☐ Tubes

Other applications .....

SCOVILL MANUFACTURING COMPANY

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Company .....

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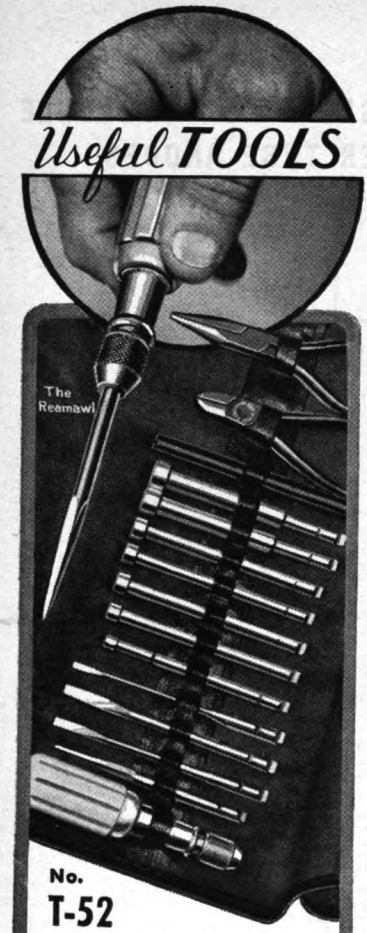

No.
T-52
SPINTITE SET.
Chuck Type Handle with Reamawl, 3 Screw Drivers, 7 SPINTITES, Insulated Neutralizing Alignment Wrench, and 2 Pliers, all in a Leatherette Roll. . . .
A Positive need in every RADIO, HOME and ELECTRICAL SHOP.
A Fascinating, Fast-Moving Item for thousands of stores. Your good jobber has it...

Send for Catalog No. 141 picturing a full line of Automobile, Aircraft and Radio Tools.

WALDEN WORCESTER WRENCHES

STEVENS WALDEN, INC.
468 SHREWSBURY STREET
WORCESTER, MASSACHUSETTS

tional Defense Research Committee, is made chairman of the Joint Board on Scientific Information Policy which will be responsible for the organization and release of scientific and allied information for OSRD, the War and Navy Departments, and the National Advisory Committee for Aeronautics.

DANIEL E. NOBLE has become general manager of the Communications and Electronics Division of

Galvin Mfg. Corp., Chicago, Ill. He retains his present responsibilities as director of research.

WILLIAM H. WILLS, former governor of Vermont, has been confirmed by the Senate as the seventh member of FCC.

CHARLES A. POWEL, president of AIEE and headquarters engineering manager for Westinghouse Electric Corp., becomes chief of the Electrical and Radio Branch of the Allied Control Commission in Germany, on leave of absence from Westinghouse.

W. G. H. FINCH, USNR, chief of the design branch, electronics division of the Navy's bureau of ships, goes from the rank of Commander to that of Captain.

AWARDS

Workers of the following concerns in the electronics field have been awarded Army-Navy "E" burgees for excellence in production:

Air King Products Co.
Brooklyn, N. Y.

Alliance Mfg. Co.
Alliance, Ohio

Garod Radio Corp.
Brooklyn, N. Y.

Presto Recording Corp.
New York, N. Y.

GOULD-MOODY
Improved
Professional Quality
"Black Seal"
ALUMINUM
INSTANTANEOUS
RECORDING BLANKS

Technological advancements brought about by our wartime assignments provide critical engineers with "Black Seal" blanks of improved cutting and reproduction qualities plus more satisfactory play-back life.

Rapid Deliveries to
Broadcasting Stations
Recording Studios
Motion Picture Sound Studios
Schools and Colleges
Governmental Agencies

Old Aluminum Blanks Recoated with "Black Seal" Formula on Short Notice

THE GOULD-MOODY COMPANY

395 BROADWAY, NEW YORK 13 N. Y.
Cable Address: Recordisc, New York, N. Y.
Export Dept: Royal National Company, Inc.
89 Broad Street, New York

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Electric Razors with Plaskon Housings

give clean, speedy shaves to servicemen

★ Recently, when Remington Electric Shavers went back into limited production, they were allocated for the exclusive use of hospitalized servicemen, and airmen whose faces are susceptible to frostbite.

The housings for these new Remington Electric Shavers are Plaskon Molded Color. This versatile plastic material lends many worthwhile advantages to the Remington Shaver.

Plaskon Materials can be molded into almost any desired shape, permitting unusual opportunity for handsome, practical designs in large quantities at very economical cost. They are available in a wide range of beautiful, permanent colors.

Plaskon Materials are strong and non-shattering, with a smooth, warm-to-the-touch surface that remains gleaming and sanitary. They are unaffected by oils or fats; alcohol, acetone, or any common organic solvents; and are odorless, tasteless and inert. They have high dielectric strength, and are completely resistant to arcing and tracking under high voltages and high frequencies.

Your products of today and tomorrow will enjoy profitable manufacturing and sales advantages if versatile Plaskon plastics can be adapted to their needs. Write for profusely illustrated booklet showing a great range of actual Plaskon applications to commercial and public needs. Experienced Plaskon men will gladly assist in adapting colorful Plaskon plastics to your individual requirements.

PLASKON

TRADE MARK REGISTERED

MOLDED COLOR

PLASKON DIVISION • LIBBEY • OWENS • FORD GLASS COMPANY • 2136 Sylvan Avenue • Toledo 6, Ohio

Canadian Agent: Canadian Industries, Ltd., Montreal, P. Q.

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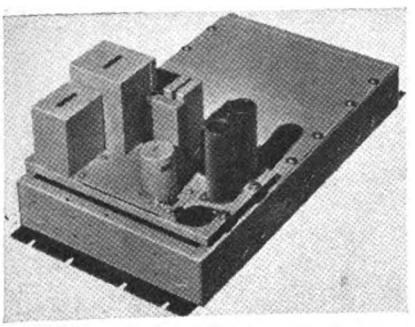
NEW PRODUCTS

Month after month, manufacturers developed new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Langevin Products

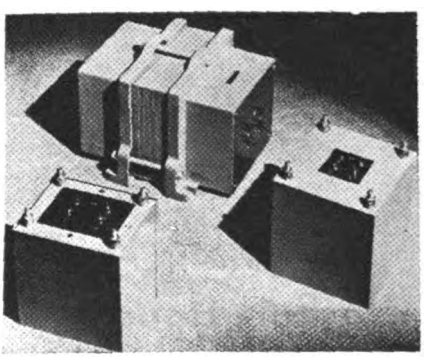
THE LANGEVIN Co., Inc., 37 West 65th St., New York, N. Y. announces three new products. The first is Type 3-A mounting frame for use in conjunction with their No. 102 Series amplifiers. The frame requires 10½ in. rack space



and will accommodate up to three of the amplifiers. It is suitable for wall mounting, rack or cabinet and panel installations. The second product is a new group of input transformers which are designated as the 400 Series. Three types are

available. No. 401-A operates from 30/250/600 ohms primary to 30,000 ohms secondary, center tapped. Type 400-C bridging unit has a nominal impedance of 600/15,000 ohms to 60,[illegible]condary. With prop[illegible] input impedan[illegible] ohms.

The third type is No. 402-A with a nominal 30/120 ohms primary to 50,000 ohms secondary. Input impedance range is 0/250 ohms. Lastly, there are three new continuous-duty auto transformers with heavy lugs on their black bakelite terminal boards. Two types (800 and 801) are also available as hermetically-sealed units. Type 800-A —primary 220 volts, 60 cycles; secondary 110 volts, 250 watts; 5AS case; measures 4⅛ x 3⅛ x 5 in. Weight 10 lb. Type 801-A—primary 220 volts, 60 cycles; secondary 110 volts, 500 watts; 6AS case; measures 5⅞ x 4⅛ x 5 in. Weight



16 lb. Type 802-A—primary 220 volts, 60 cycles; secondary 110 volts, 1000 watts; housed in a No. 6 casting poured with humidity-proof compound; measures 9¼x7¼x6¾ in. weight 33 lb.

Capacitors

CASE STYLES CP-50, 51, and 52, characteristic F, are an addition to a complete line of fixed paper-dielectric capacitors recently announced by General Electric Co., Schenectady, N. Y. These capacitors meet government requirements for use in electronic communication and locating equipment for the Armed Forces. Al
available
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Weight vari
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is the locat
Bulletin No.

Dual Ampl

PLANT BROAD
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Soundcaster,
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record turn
the amplifie

Radio Filt

LOW-RESIST
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mitters or
tions are a
special size
expanded n

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DeJUR

20 . . . A New DeJUR Miniature Meter . . . precision instrument ermanent accuracy in small panel space. Conforms to forthcom- specification . . . self-contained up to 1 ampere and 150 volts. C. (rectifier) . . . external shunts or multipliers . . . in a wide ranges.

MAGNETS . . . highest grade . . . provide stability and quick nder high torque, with increased protection against magnetic

EXTERNAL PIVOTS . . . insure maximum accuracy . . . reduce pointer-rocking, side friction between jewels and pivots, and wear on bearing surfaces.

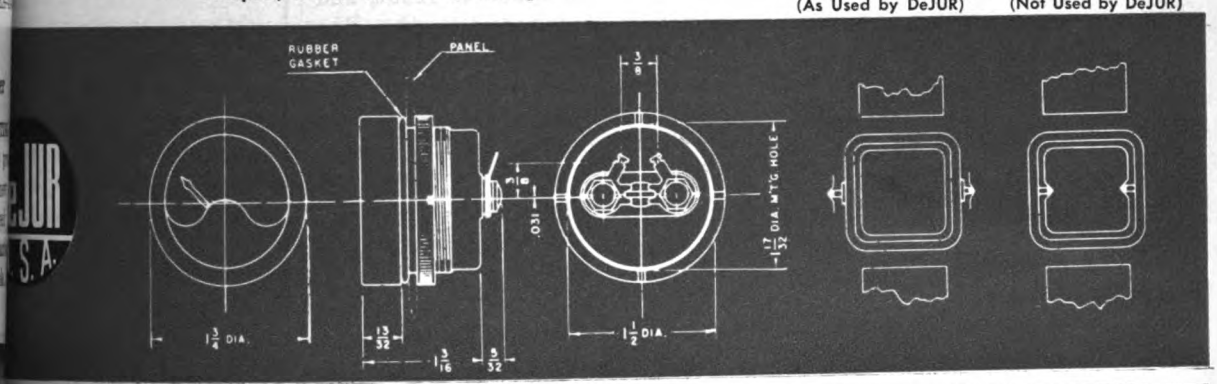
EXTRA-TIGHT SEALING . . . completely waterproof . . . in addition, rubber gasket seals flange to panel. Model 120 is particularly adapted for water-proof equipment.

For full information on DeJUR Miniatures and special applications, write

DeJUR-AMSCO CORPORATION, Long Island City 1, N.Y.

Compact, Trouble-Free Modern Design

External Pivot (As Used by DeJUR) **Internal Pivot** (Not Used by DeJUR)



AMMETERS . . . VOLTMETERS . . . POTENTIOMETERS

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INSPECTION PROBLEMS

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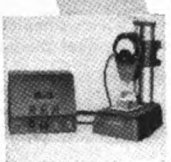
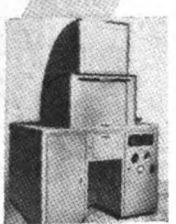
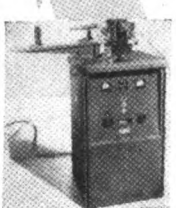


ECTRONIC COMPARATOR



X-RAY UNIT



DIFFRACTION UNIT

Modern Electronic Inspection methods bring a new, high degree of speed, accuracy, and economy to this production operation. Today's inspection equipment is designed to keep pace with modern production methods. Its amazing efficiency is best employed when expert W-J inspection engineers make a study of *your* requirements and apply the equipment ideally suited to your needs. Let us show you the applications of X-Ray machines, diffraction units, spectrometers, electronic comparators, photoelectric units and electronic measuring equipment, to your particular problems! Fill in and mail the coupon *today!*

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CANal 2525

manent and effective in keeping dust particles out of radio apparatus. Badger Corp., Milwaukee 12, Wis.

Voltage Testing Device

IMPROVEMENTS featured in the new RCA 195-A Voltohmyst include a diode for a-c measurements, a linear a-c scale for all ranges, a new crystal-clear plastic meter case with

a one-piece unbreakable front, and shielded a-c cable and probe. The instrument combines in one unit the means for measuring d-c or a-c voltage, resistance, audio level, and f-m discriminator balance. RCA Victor Div. of Radio Corp. of America, Camden, N.J.

Non-Corrosive Flux

ORIGINALLY developed for the Armed Forces, Zenith non-corrosive Super Flux is now available to the industry for use in soldering electrical connections or as a soldering flux on copper, cadmium-plated brass and steel, and black steel. It can also be used to facilitate tinning of soldering tips. The flux is easily applied by brush or dipping and readily adheres to the work. Polan Industries, Huntington 19, W. Va.

Relay Connector

CANNON ELECTRIC Development Company (3209 Humboldt St., Los Angeles 31, Calif.) announce that their Type RR-1 and RR-2 railroad signal relay connectors are adaptable to all types and makes of relays in test requirements. The complete connector is made up of a plug and receptacle, having phenolic shells. Two guide posts assure correct polarization. These connectors are adaptable to 4 to 6-point relays.

• M A

CATHODE TUBE SHIE

. . . to meet your tions. These are on our many available

• FABRICATE Mu-Metal or Ni

• TESTED by use to meet all ments

• DESIGNED your needs

★ ★ ★ ★

* * Our engineers any metal — shie cabinets, etc. for y application

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METALLIC ART 243 a Br CAMBRIDG

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For Quick Visual Indication

Investigate the Unique Characteristics of G-E Neon Glow Lamps

...ique characteristics of Gen-...lectric Neon Glow Lamps ...d them for a variety of uses ... and electronic devices . . . as ...rs, voltage regulators, pilot ...d test lamps.

The uses described at right are typical. If you think G-E Neon Glow Lamps can be useful to you, write or phone the address below. Experienced General Electric Lamp Engineers will be glad to discuss your problems with you.

NE-51 For general indication, such as showing existence of potential across various parts of electrical circuits.

NE-17 Indicator and pilot light lamp that flashes to show condition of B-battery in portable radios. Frequency of flashes decreases as battery runs down.

NE-48 (also N-E 16). Indicator lamps. Special volt-ampere characteristics of these lamps indicate use as voltage regulators. Screw base lamp available as NE-45.*

*NE-16 meets JAN-1A specifications for 991. Special marking JCG-991 supplied for small extra charge.

CONSIDER THESE ADVANTAGES

1. Distinctive orange-red glow — no colored cover glass needed.
2. Dependable performance and long life — rated at 3,000 hours.
3. Very low current consumption — less than ½ milliampere for smallest lamp.
4. Variety of sizes and wattages.
5. High resistance to vibration, shock.
6. Normally usable on a-c or d-c.
7. Screw base lamps for 105-125 v. circuits; similar lamps available with bayonet bases, but external resistance required.
8. Produce practically no heat.
9. Nearly flat volt-ampere characteristics.
10. Insensitive to voltage variations above critical value.

	NE-2	NE-51	NE-17	NE-48	NE-16 ④	NE-45	NE-30	NE-32	NE-34	NE-36	NE-40	NE-42
Watts	⅛	⅛	③	¼	¼	¼	1	1	2	2	3	3
Volts	105-125	105-125	③	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Cycles	65 90	65 90	③	65 90	— ⑤	65 90	60 85	60 85	60 85	60 85	60 85	60 85
Base	★Unbased (Wire Terminals)	★S. C. Bay. Min.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	Cand. Screw	Medium Screw	★D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.
Bulb ②	1¼"	1⅜"	1½"	1½"	1½"	1⅜"	2⅛"	2"	3⅝"	3¾"	3⅝"	3¾"
Price	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

...ump when new.
...ort; wire terminals extend additional 13/16".
...ed for DC flashing operation in RC circuit.

④ Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
⑤ Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).
★ All Bayonet Base Lamps Need External Resistance.

For further information, write address below for Bulletin 7100

NELA SPECIALTY DIVISION, LAMP DEPARTMENT

GENERAL ELECTRIC

1 Newark Street, Hoboken, N. J.

...September 1945

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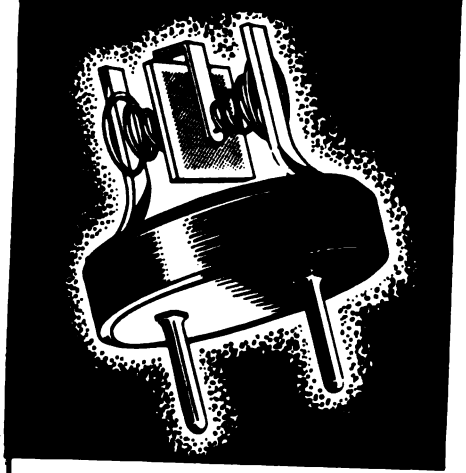
Specialists in Special Crystals



100 KC FREQUENCY STANDARD CRYSTAL

. . . Designed to withstand severe shock and vibration. A crystal so precisely finished that it has less than 15 cycles drift from -50C to +85C*. (If oscillator or circuit is furnished, an accuracy of 3-5 cycles can be obtained) . . A special solder bead supports a tensile load of 9,000 lbs. per square inch. Crystalab engineered to meet the most rigid operating requirements.

*Also available in frequencies from 80.86 to 200 KC.

Yankee Ingenuity makes us

Write Dept. E.L. for comprehensive catalogue "Selectronic Crystals" and facilities booklet "Crystalab Solves a Problem".

CRYSTAL RESEARCH LABORATORIES

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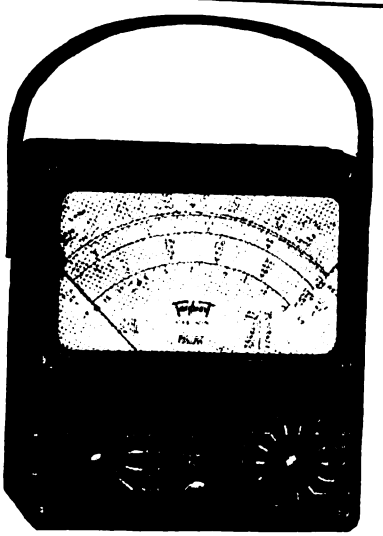
LABORATORIES AND MAIN OFFICE 29 ALLYN STREET, HARTFORD 3, CONN.

New York Office 15 E. 26th Street, New York 10, N. Y. Phone M. H. 5-2852



Here's that New TRIPLETT 625-N

Long Scale, Wide Range Volt-Ohm-Milliammeter

DIRECT READING OUTPUT LEVEL DECIBEL RANGES
—30 to +3, +15, +29, +43, +55, +69 DB

TEMPERATURE COMPENSATED CIRCUIT FOR ALL CURRENT RANGES D.C. MICROAMPERES
0-50 Microamperes, at 250 M.V.

D.C. MILLIAMPERES
0-1-10-100-1000 Milliamperes, at 250 M.V.

D.C. AMPERES
0-10 Amperes, at 250 M.V.

OUTPUT READINGS
Condenser in series with A.C. Volts for output readings.

ATTRACTIVE COMPACT CASE
Size: 2½" x 5½". A readily portable, completely insulated, black, molded case, with strap handle. A suitable black, leather carrying case (No. 629) also available, with strap handle.

LONG 5" SCALE ARC
For greater reading accuracy on the Triplett RED •DOT Lifetime Guaranteed meter.

SIMPLIFIED SWITCHING CIRCUIT
Greater ease in changing ranges.

DOUBLE SENSITIVITY D.C. VOLT RANGES
0-1.25-5-25-125-500-2500 Volts, at 20,000 ohms per volt for greater accuracy on Television and other high resistance D.C. circuits.
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

A.C. VOLT RANGES
0-2.5-10-50-250-1000-5000 Volts, at 10,000 ohms per volt.

OHM—MEGOHMS
0-400 ohms (60 ohms center scale)
0-50,000 ohms (300 ohms center scale)

Write for descriptive folder giving full technical details.

Triplett ELECTRICAL INSTRUMENT CO., Bluffton, Ohio

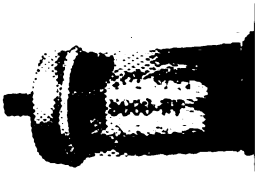
Reproducer for Rai

TYPE NJ-300 REPRODUCE inally designed for Nav loudspeaker and micropl back) unit but it is no for all types of railroad motives, cabooses, sign and out-doors in railr The reproducer consist NF-300 speaker (describ issue) enclosed in a

road-type cast aluminum unit can be mounted in tion. It is rugged and is withstanding shock and as well as prolonged ex smoke, dust and other Voice coil impedance is ra ohms nominal value. Po dling capacity for speech 10 W. Jensen Radio Mfg. S. Laramie Ave., Chicago

High-Temperature Capacitors

PLASTICON, Type AS, silic pregnated, plastic film, capacitors are capable of ous operation at 256 F. The are light and compact, and used at maximum tempera full voltage rating. They a



only to specification in all tances and voltage ratings varieties of standard and cans, and in the Glassmik struction. An 0.01 μf, 5000 ing volts, Plasticon Type measures 1¾ in. long x ¾ in Condenser Products Co., 1 Branch St., Chicago 22, Ill.

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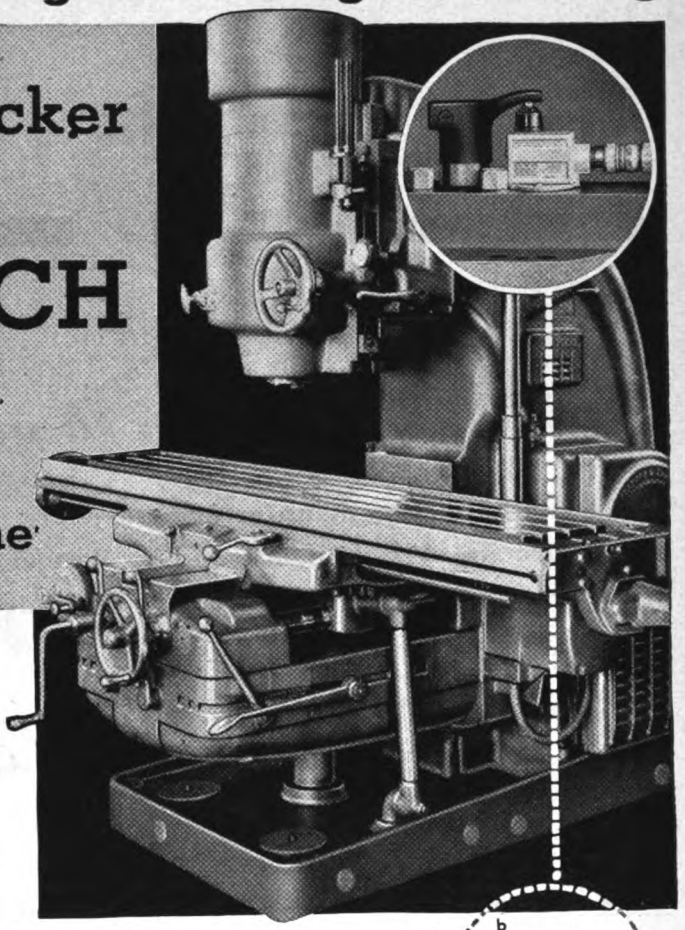
Positive Angle on Negative Angle Milling

ow Kearney & Trecker Use MICRO SWITCH SNAP-ACTION As Inching Switch on ilwaukee Milling Machine



HEN Kearney & Trecker designed this big new 50 HP. C.S.M. Milwaukee Milling Machine, ly for negative angle milling, it was important e inching switch, used for synchronizing gears, ged and dependable. A Micro Switch sealed switch with a die cast housing was installed it is operated by an actuator head controlled inching button.

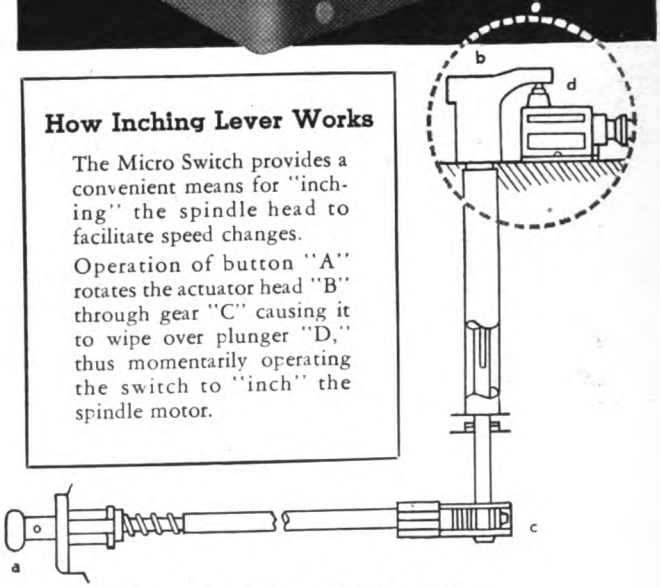
switch was selected because it combined the ion, capacity, and durability required by the g machine manufacturer. Micro Switch snap- can be counted on for millions of operations, qually accurate. There are over 2700 different inations of switches, contacts, actuators, and osures.

for the Handbook-Catalog No. shown at right—it gives specific, ful information on Micro Switch ducts.

How Inching Lever Works

The Micro Switch provides a convenient means for "inching" the spindle head to facilitate speed changes.

Operation of button "A" rotates the actuator head "B" through gear "C" causing it to wipe over plunger "D," thus momentarily operating the switch to "inch" the spindle motor.



Send for this free Handbook-Catalog

Gives complete details as to electrical characteristics, construction, dimensions, operations, and applications. If you are specializing in aircraft equipment, ask for Handbook-Catalog No. 71, also.

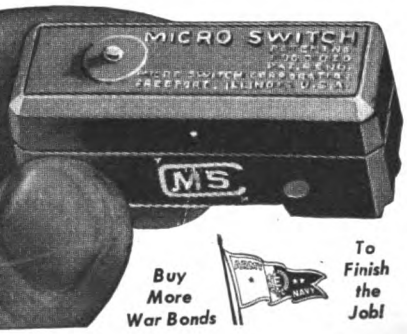
© 1945 First Industrial Corporation

MICRO MS SWITCH

TRADE MARK

A DIVISION OF FIRST INDUSTRIAL CORPORATION

Freeport, Illinois, U.S.A., Sales Offices in Principal Cities



Buy More War Bonds

To Finish the Job!

The basic switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, Underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a. c. Capacity on d. c. depends on load characteristics. Accurate reproducibility of performance is maintained over millions of operations. Basic switches of different characteristics are combined with various actuators and metal housings to meet a wide range of requirements.

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For more than 10 years

we have been manufacturing crystals. Not only are we crystal manufacturers, but crystal specialists as well. Consult us on your "crystal problems".

★

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Council Bluffs, Iowa

CRYSTALS EXCLUSIVELY SINCE 1934

Increased service-

result of tough precision-fabricated materials

Exceptional electrical and mechanical properties of fibre parts, when fabricated with accuracy and precision, greatly expand product service-life. Vulcanized fibre with resistance to oils, fumes, corrosion, impact and vibration, and phenol fibre with resistance to moisture absorption, represent two materials particularly adaptable to many applications. BAER facilities for stamping, punching, drilling, milling, machining, and sawing completes the solution for close tolerance fabrications.

Baer

PHENOL AND VULCANIZED

FIBRE

FABRICATIONS

FOR INDUSTRY

LITERATURE ON REQUEST. The BAER fibre fabrication data bulletin—crammed with pertinent information and specifications relating to both phenol and vulcanized fibre—will be sent promptly on request on company letterhead. Write for Bulletin 120.

N. S. BAER COMPANY, 9-11 MONTGOMERY ST., HILLSIDE, N. J.

Regulated Power Su

A NEW SERIES of satura regulated power supplie developed by Amplifi America (398 Broadw York 13, N. Y.) for a requiring d-c voltages re better than 5 percent fro to no load, and having l percent ripple under These units may be used battery substitutes or d-c generators. Standa packs available in this r are rated 24-v, ½ amp o 48 v, 1¼ amp or 5 amp; a tion 24 and 48 v, 750 m amp; 110 v, 8 amp; 120 v 135 v, ½ amp; 250 v, 4 a 200 ma. These power pac furnished with built-in voltage regulators to co for line voltage changes.

Smoke Detector

A PHOTOELECTRIC control which detects smoke in a tioning ducts is annou Photoswitch Inc., 77 B Cambridge 42, Mass. The consists of photoelectric Type A26X and light sour

L11RX. The latter may be m to project a beam of ligh any distance from 10 to 25 f intensity of the light beam m set so that the control wi spond to smoke of a predeter density.

Electronic Generator

MODEL NO. RL-1 IS a variable form, variable frequency elect generator manufactured by R Television Institute, Inc., 480

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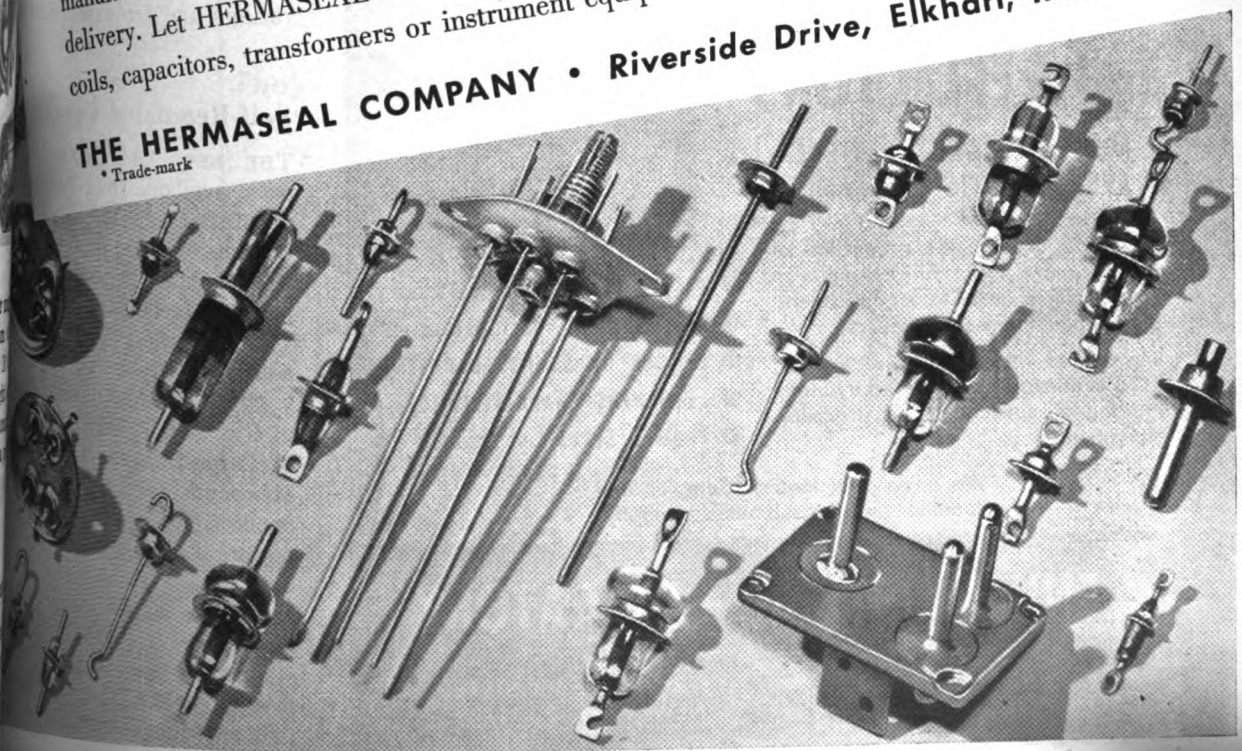
HERMASEAL*

for TRUE and PERMANENT Hermetic Sealing

Literally hundreds of different types of glass and metal seals have been engineered by HERMASEAL to meet today's exacting demands for military electronic equipment. • HERMASEAL engineers have been actively engaged in the solution of glass and metal seal problems for the last 17 years and have pioneered many of today's accepted standards in hermetically sealed enclosures. • We specialize in building seals to meet the manufacturer's requirements; however, accepted standard seals are available for immediate delivery. Let HERMASEAL solve your problem of hermetic sealing whether it be relays, coils, capacitors, transformers or instrument equipment. For fast action *write, wire* or *call*

THE HERMASEAL COMPANY • Riverside Drive, Elkhart, Indiana

* Trade-mark



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The Employees and Management of

The Benwood-Linze Company

and

The B-L Electric Manufacturing Company

are honored to announce that the

Army-Navy "E" Production Award

for Excellence in War Production

was made to the company on

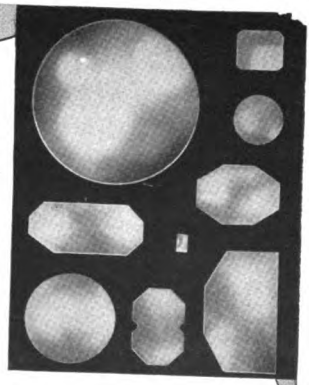
Thursday, August twenty-third

Nineteen hundred and forty-five

OPTICAL

MIRRORS and REFLECTORS

FOR ELECTRONIC, OPTICAL AND SCIENTIFIC APPARATUS



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- PROMPT SERVICE

We invite your inquiry. Samples and quotations will be submitted promptly.

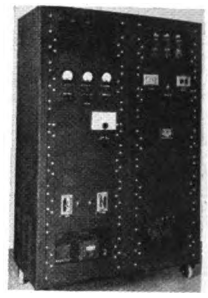
ZENITH OPTICAL LABORATORY

SPECIALISTS IN VACUUM DEPOSITION

Z OPTICAL LAB

123 WEST 64th STREET
NEW YORK 23, N. Y.

ington Ave., New York 17, N. Y. A feature of the unit is its ability to maintain essentially constant rms output voltage while permitting variation of waveform and frequency. The waveform of the output voltage can be carried from nearly square wave through sine wave to peaked wave covering amplitude factors (ratio of peak to



rms volts) of from 1.16 to 1.65. The frequency is variable over a range from 50 to 2400 cps. Output voltage is 115 v rms nominally, adjustable between 110 and 120 v. Regulation of output voltage is better than 3 percent from no load to 300 w, and for line voltage changes from 110 to 120 v a-c. The output voltage stays within the same limits for frequency changes over the whole range, as well as for changes in amplitude factor from 1.16 to 1.65. Units can be designed for other output voltage and power ratings and frequency ranges.

Self-Regulated Power Pack

THE NEW TAC MODEL 1220-EB pack, available from Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass., provides two voltage-regulated d-c outputs on ranges used for anode and bias voltages. The high-voltage output is continuously adjustable from zero to 400 v with voltage automatically held at its initial setting under load variation from zero to full current. Maximum current output on the anode supply is 250 ma; maximum power output is 40 w. Regulated bias voltage is continuously adjustable from minus 100 v to zero at maximum current of 2 ma. The instrument is assembled with oil-impregnated oil-filled capacitors, and it is anti-fungus treated.

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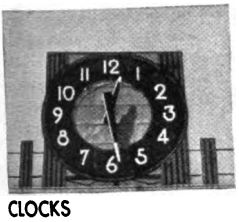
B-L METALLIC RECTIFIERS

SELENIUM COPPER SULPHIDE

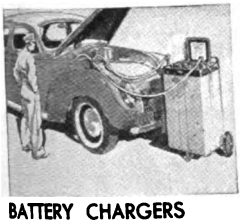
A few B-L Rectifier applications are illustrated below:

AUTO RADIOS

PIPE ORGANS

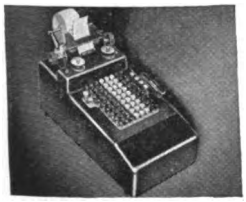


CLOCKS



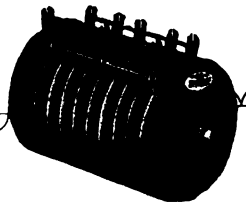
BATTERY CHARGERS

FIRE TRUCKS



BUSINESS MACHINES

from AC →



→ to DC

B-L METALLIC ELECTRICAL RECTIFIERS (SELENIUM COPPER SULPHIDE)

offer you these advantages:

***They are* COMPACT**
For a given power output the space required by metallic rectifiers is very small.

***They are* SILENT**
B-L Rectifiers are silent in operation and have no moving parts.

***They are* DEPENDABLE**
Dependability is assured by their simple and rugged construction, in which no glass bulbs, filaments, or other fragile parts are employed.

***They are* TROUBLE-FREE**
Regular maintenance and attention are unnecessary.

***They are* RUGGED**
B-L Rectifiers are rugged and will withstand heavy overloads for short periods of time.

***They are* ADAPTABLE**
B-L Rectifiers are adaptable for power outputs from Milliwatts to Kilowatts.

Many rectifier applications, heretofore considered impractical, have been devised by B-L Engineers. It is more than likely that they can be of assistance in solving your problems of converting AC current to DC... Write for Copper-Sulphide Bulletin R38-A — or for Selenium Bulletin R41-A.

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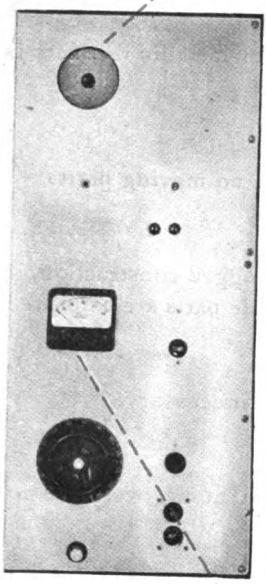
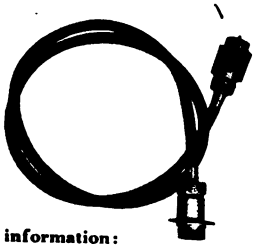


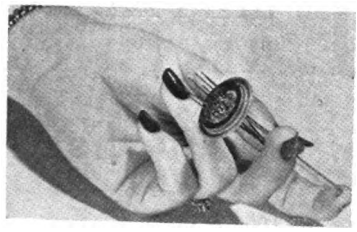
TESTED:
for *breakdown* . . .
any strength up to 30,000 volts



Full information:
COLUMBIA
Electronics, Inc.
185 East 122 Street,
New York 35, N. Y.
LEhigh 4-5100

Airtight Steel-To-Glass Seal

A NEW METHOD of fusing steel and glass in a permanent airtight seal for metal electron tubes has been revealed by Dr. G. R. Shaw, Chief Engineer of the Tube Division of the Radio Corporation of America, Harrison, N. J. The method provides a more foolproof process, and



permits the use of steel for the glass-to-metal seal in place of special alloys. Steel was used for the header insert (the ring-like band of metal encircling the glass button through which the wire leads are introduced into the tube) shown in the illustration.

Handie-Talkie Production

PORTABLE handie-talkie sets are being made for civilian use for farms, ship-to-shore communication with small boats, manufacturing operations, etc. by John Meck Industries, Inc., Plymouth, Ind. FCC has assigned a band of 460-470 mc for handie- and walkie-talkie use by civilians.

Electrical Insulation

THE VARFLEX CORP., Rome, N. Y., has developed and is now producing a new type of electrical insulation based on the silicone high-temperature resins in combination with normalized Fiberglas. It is made in various grades of tubing,

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From the first projection of design, through all stages of OLYMPIC metal parts fabrication—production, tooling, forming, stamping, grinding, welding, brazing and soldering—emphasis is placed on quality. By experience gained in meeting existing essential needs, OLYMPIC engineers are ready to supply your postwar requirements. Design ingenuity, resourceful engineering and precision workmanship will materially aid in meeting tough production schedules, close tolerances and fabrication intricacies.

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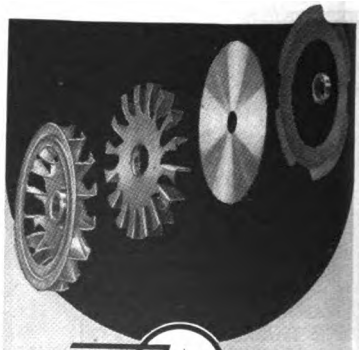

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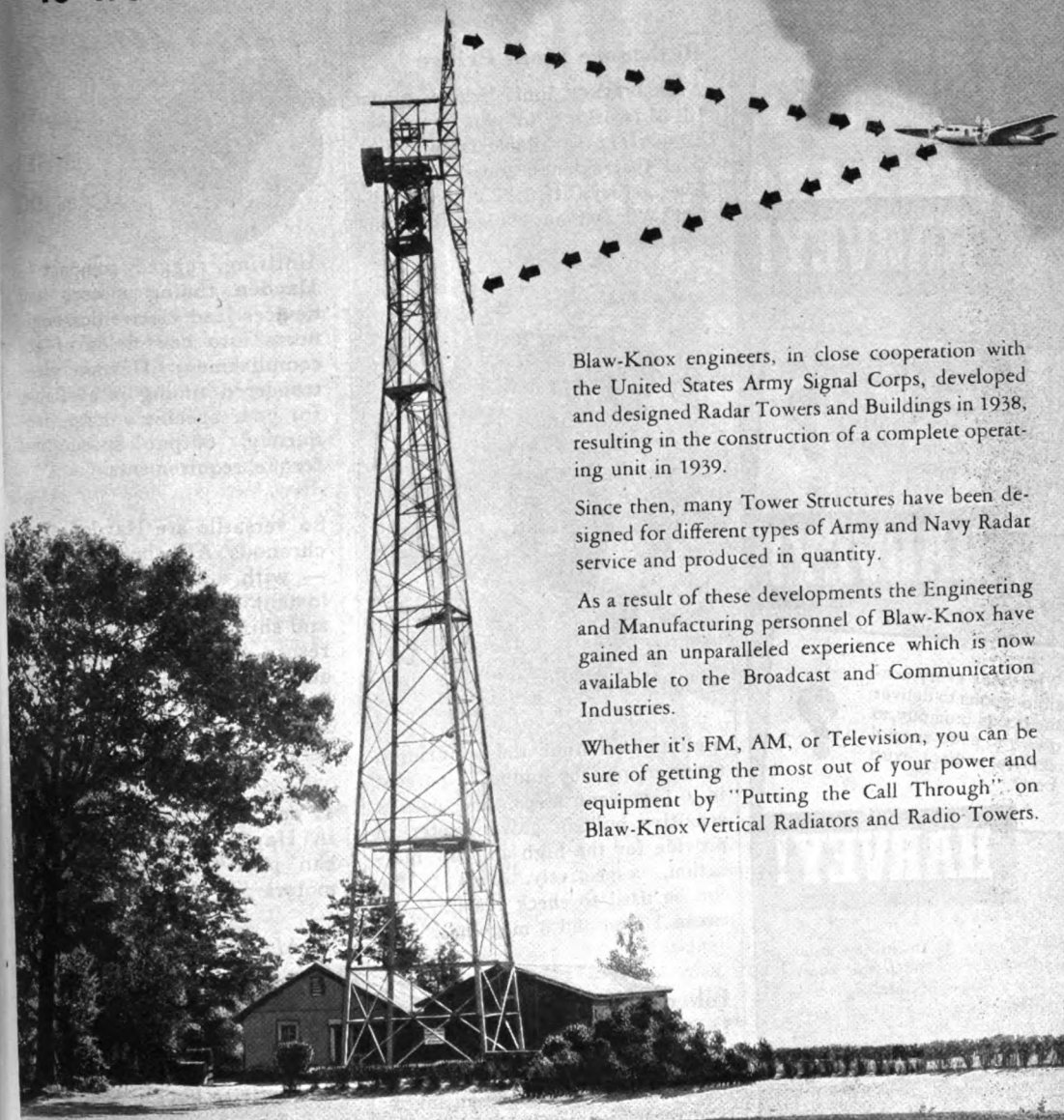
RADAR

is not new to the Blaw-Knox Company



Blaw-Knox engineers, in close cooperation with the United States Army Signal Corps, developed and designed Radar Towers and Buildings in 1938, resulting in the construction of a complete operating unit in 1939.

Since then, many Tower Structures have been designed for different types of Army and Navy Radar service and produced in quantity.

As a result of these developments the Engineering and Manufacturing personnel of Blaw-Knox have gained an unparalleled experience which is now available to the Broadcast and Communication Industries.

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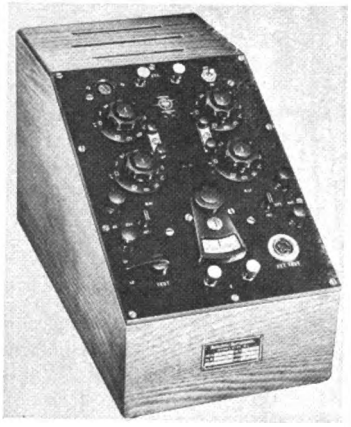
sleeving, and tying cord, and can be furnished on some types of wire and cable. Silflex sleeving can be tied in knots and chafed at −85 F. It remains flexible and physically stable at + 450 F indefinitely. Literature and a sample card showing the various types of insulation available will be sent by Varflex Corp.

Resistance Limit Bridge

A RESISTANCE limit bridge, Model LB-3 (working to plus or minus 0.1 percent) available from Industrial Instruments, Inc., 17 Pollock Ave., Jersey City 5, N. J., is a modified Wheatstone bridge that has



high and low limit dials covering a range of plus or minus 11 percent in 0.1 percent steps, and uses a sensitive built-in galvanometer to provide for the high and low indication, respectively. This bridge can be used to check resistors between 1 ohm and 3 megohms.

Inked-Tape Recording Device

MECANITRON Corporation of Boston, Mass., has developed an inked-tape recording device which is designed for continuous high-speed reception and which is capable of receiving 1200 words per minute. This device is designated as Mecanitron Model MA-126. This unit comprises two complete recorder heads and pulse amplifiers. Inputs of the amplifiers are connected in parallel and are energized simul-

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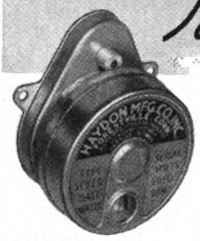

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So versatile are Haydon synchronous AC timing motors — with automatic brake for instant stop, reversible feature and shift device for automatic reset — that application of automatic timing is being found practical in countless instances where never used before.

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*ELECTRONEERED TIMING

Haydon

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Forestville, Connecticut

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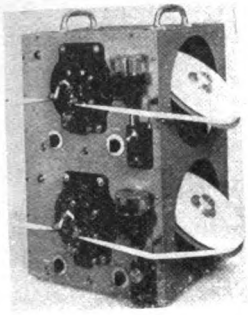
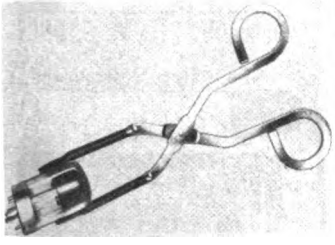
taneously from the same source. A stand-by switch is provided on each unit so that either recorder will function instantly on the same information. This allows the second recorder to carry on without interrupting the flow of high-speed material during the interval re-



quired to provide a new roll of tape for the first recorder. The Model MA-126 can also be furnished for relay rackmounting. It operates on either 110-220 volts, 60 cycles, or 220-230 volts, 25-50-60 cycles. Designed for efficiency at a rate of 1200 words per minute, the unit handles low and average speeds with ease.

Tube Extractors

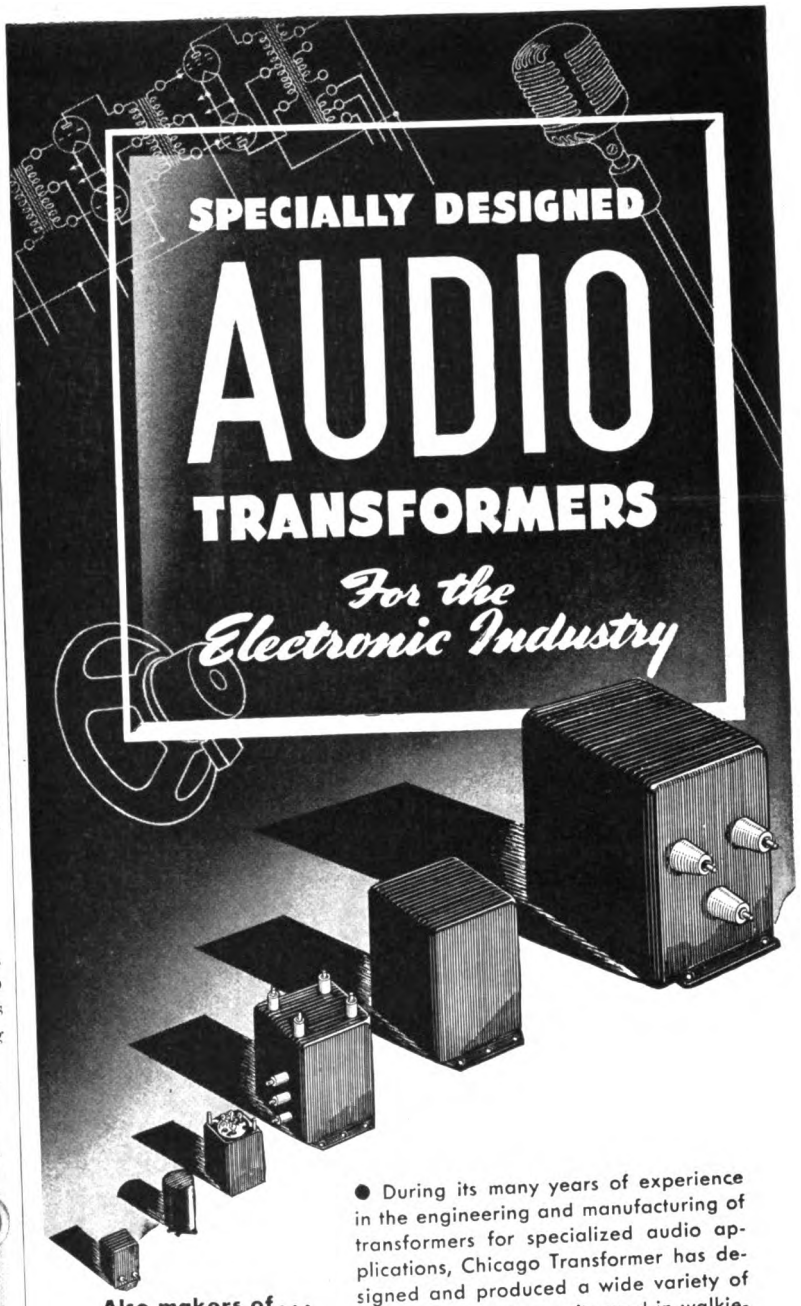
THE BMG COMPANY of Boonton, N. J. announces a new addition to its "Sure-Grip" tube extractors used in the inserting and extracting



of delicate miniature and straight-side glass radio receiving tubes manufactured in standard bulb sizes T5½, T7, T8 and T9.

Low-Voltage Rectifiers

ILLUSTRATED IS a stabilized low-voltage rectifier manufactured by Green Electric Co., 130 Cedar St., New York, N. Y. It is rated at 200 amp, voltage range zero to 3 v. Any voltage selected in the range is maintained to within 50 millivolts



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● During its many years of experience in the engineering and manufacturing of transformers for specialized audio applications, Chicago Transformer has designed and produced a wide variety of types, from the tiny units used in walkie-talkies to large size modulation transformers. If you have a design problem involving transformers in audio or other types of circuits, let this well qualified organization be of service to you.

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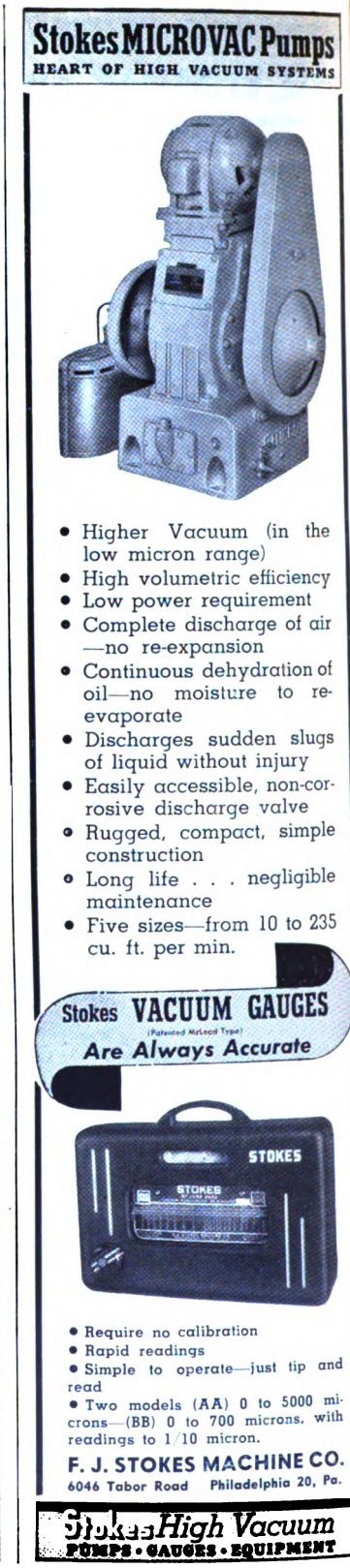

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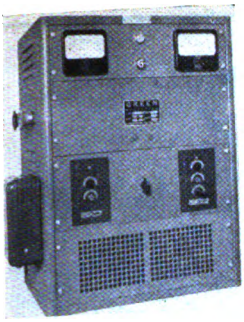
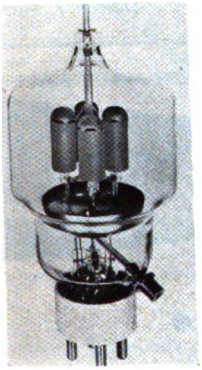


over load variation from zero to 200 amp, and with line voltage variation of plus or minus 10 percent. The unit's voltage stabilization system includes a motor-driven Powerstat and a simple electronic pilot device.

Triode Tube

ILLUSTRATED is a new type 304TL (3-300B2) multi-element triode which incorporates a new design plate and a non-emitting grid to assure maximum tube life and high efficiency. The tube has many ap-



plications including television and industrial heating. Data sheets are available from the manufacturer, Eitel-McCullough, Inc., 478 San Mateo Ave., San Bruno, Calif.

Non-Linear Potentiometer

THE FAIRCHILD Camera and Instrument Corporation (475 Tenth Ave., New York 18, N. Y.) announce a non-linear wire-wound potentiometer which has a high degree of operating accuracy. The manufacturer states that tolerances of one-half percent or better have been consistently reached for certain curves. Developed originally for use in bridged T attenu-

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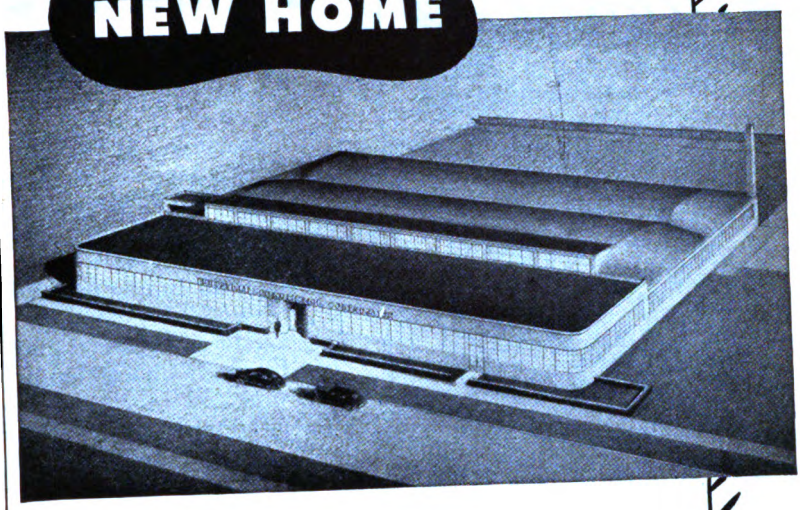

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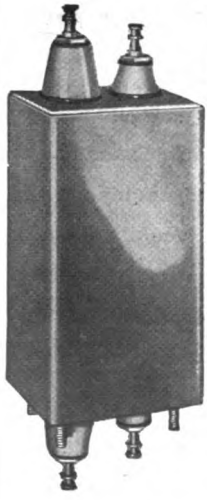

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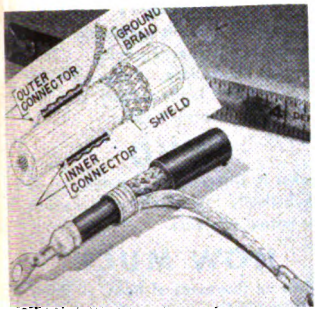
ators in Fairchild's airborne electronic computing gunsights, the potentiometer is at present available to industry in one standard size (1¼-in. outside diameter). It can be used singly, or stacked. Other features of the unit include good flexibility for reproducing any desired curve within certain limits, small size, long life with sustained accuracy, and the ability to replace more costly alternative circuits and components.

Connectors

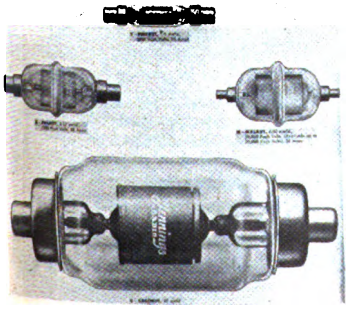
DESIGNED especially to simplify the making of connections, taps, and splices in coaxial and shielded cable are connectors announced by Burndy Engineering Company (17



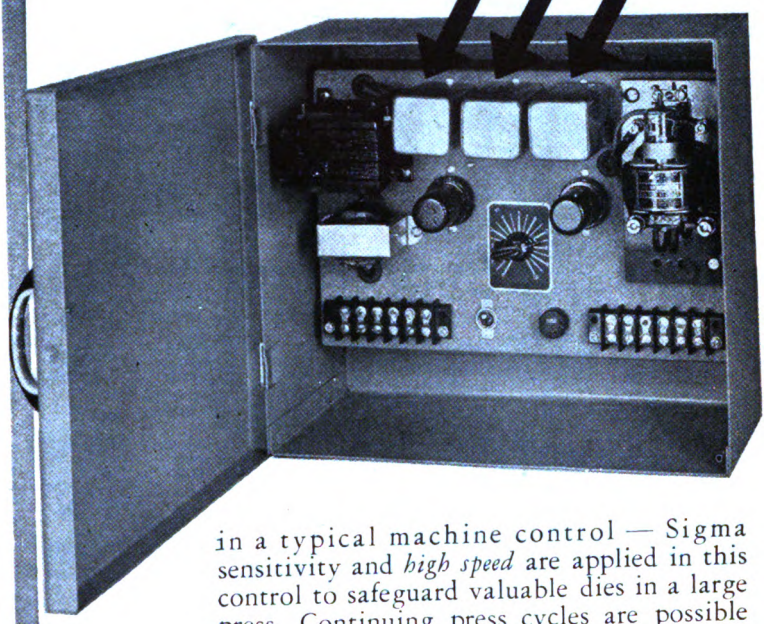
Bruckner Blvd., New York 54, N. Y.) as an addition to their line of Hydant products. The connectors aid in the elimination of soldering and minimize the possibility of insulation being damaged by heat.

High-Vacuum Capacitors

JENNINGS RADIO Mfg. Co., 1098 E. William St., San Jose, Calif., announces four new high-vacuum capacitors ranging from 1 $\mu\mu$f at 7½ amp, 3,000 peak volts to 250 $\mu\mu$f at 60 amp, 20,000 peak volts and a special high-power unit rated 50,000 peak volts. Capacitors are



here are 3 SIGMA RELAYS



in a typical machine control — Sigma sensitivity and *high speed* are applied in this control to safeguard valuable dies in a large press. Continuing press cycles are possible only as each formed piece is ejected and monitoned by the control.

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Speed	Sensitivity
Long Life	Compactness
Stability	Precision

Now is the time to let our Engineering Department know what additional specific features will be required in relays for your product. We intend to design new relays for expressed demands first. Do you need —

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- Higher Power Handling Capacity ?
- Polarized Relays ?
- Differential Operation ?
- Snap-Action Contacts ?
- A-C-relays ?

Write and let us know the relay features which would be specifically useful to you, *especially those not now obtainable in existing relays.*

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Where surpassing precision and longest dependability are essential objectives in your product—present or post-war—you can not afford to take chances. Make sure with Tel-air!

Teleoptic Directional Signals for the highway are made to the same standards of accuracy and dependability.

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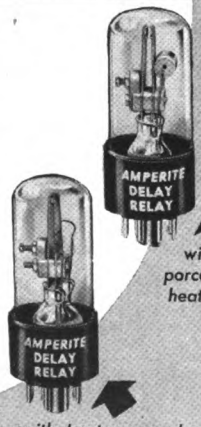

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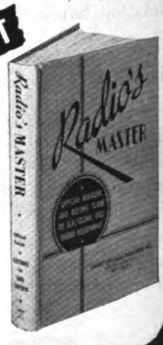

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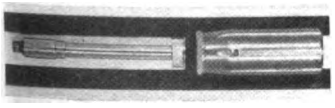
available in small enough sizes for aircraft and mobile police equipment and in larger units for heavy industrial electronic equipment.

Crystal and Holder Assembly

CRYSTAL AND holder assembly, designated as the MX-9 Series, is a high-quality Brazilian quartz crystal mounted in a dust and moisture-proof holder designed to fit a standard 3-prong crystal socket. It is designed for frequency control in communication and experimental service. (The frequency is specified by the customer.) All units are calibrated against a primary frequency standard which maintains an accuracy of one part in five million. Frequency range is 250-10,000 kc; frequency accuracy is rated at a tolerance of 0.01 percent of the specified frequency at 20 C is maintained for all frequencies between 250 and 1200 kc. Between 1200 and 10,000 kc, this tolerance is 0.02 percent of the specified frequency; temperature range between minus 40 and plus 55 C. Bendix Radio, Baltimore, Md.

Torque Tool

SPEED AND COMFORT in operation are features of a spintite-style tool designated as "Tork-Tite" which makes possible torque tightening in inch-ounce settings in precision instruments. The torque-limiting action of the tool eliminates possibility of over-tightening and assures accuracy where sensitive and definite torque accuracy is required



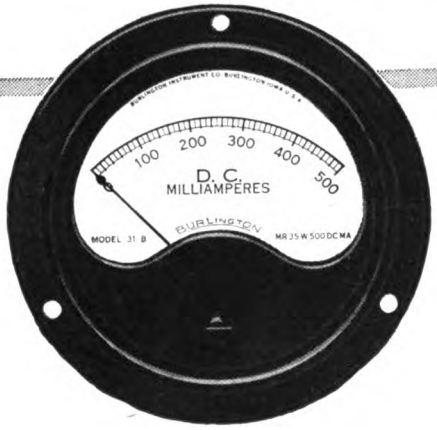
for assembly or laboratory work. The tool is available in two models, with either fixed or adjustable torque setting. The adjustable model is quickly set to a desired torque reading in the handle. Skyway Precision Tool Co., 3217 Casitas Ave., Los Angeles 26, Calif.

Screen Booth Filter

A NEW POWER-LINE filter for use with screen-rooms prevents entrance of objectionable line noise at all frequencies from 150 kc to 400

Burlington

PANEL INSTRUMENTS



Guaranteed ACCURACY

Due to design characteristics and close control of manufacturing processes, Burlington instruments embody the following advantages:

PERMANENCE OF CALIBRATION . . . All DC instruments employ Alnico magnets which are known to be more highly resistant to shock, heat, vibration, and stray fields than any other magnetic material.

FREEDOM FROM STICKING . . . Clearances for all moving parts are such that the results of entrance of small particles as encountered in field service are reduced to a minimum.

STABILITY OF OPERATION . . . All instruments are "NORMALIZED" after assembly to eliminate "zero shift" and other calibration errors due to ageing.

Exceptionally high torque to weight ratio of control springs to moving element insures minimum error under conditions of shock, vibration, and other rough usage.

Alignment of jewels and magnet core piece is such that the center lines of these parts coincide within plus or minus .002". The design of the brass movement frame and components is such that mechanical tolerances are reduced to a minimum in assembly. As a result, jewel and pivot wear is uniform which reduces "frictional torque" of the moving coil.

All series resistors and coils are heat treated and impregnated after wrapping to insure stability and long life.

All ranges AC & DC are available in 2½", 3½" and 4½" sizes, both square and round, flush mounting.

Engineering service furnished for specialized applications.
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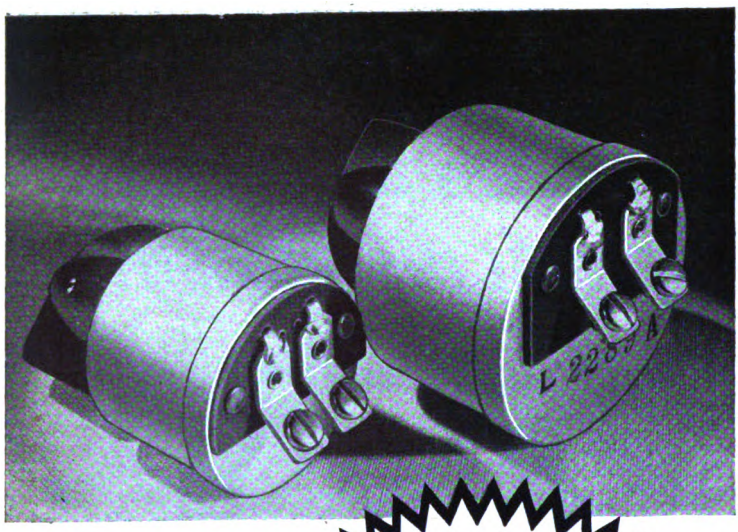

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POWER Rheostats

★

Insulated metal core supports resistance winding. Winding imbedded in "Greenohm" cold-setting inorganic cement.

★

Normal current rating may be exceeded by 50% at any setting up to 1/3 total rotation, without damage.

★

Rotor design provides smoothest rotation and positive conduction at all settings.

★

1 to 5000 ohms in 25 watt; ½ to 10,000 ohms for 50-watt.

★

Detent action, hop-offs, special shafts, different terminals, etc. available on special order.

★ Hundreds of thousands of these Clarostat power rheostats are now in daily use. They are standard equipment in radio, electronic, aircraft and other wartime assemblies. Likewise in more and still more industrial equipment. They are proving that they "can take it"—and then some. No tougher controls are made.

The 25- and 50-watt units here shown are of the enclosed or protected type. Uncased units are also available, where the casing is not required. Wide choice of resistance values.

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Controls and Resistors

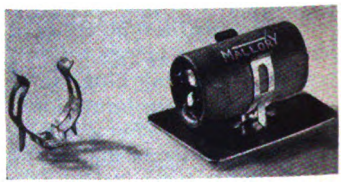
CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

mc. The unit is designed for continuous operation at 500 v d-c or a-c at a full-load current of 100 amp.

It is available for installation in two-wire and three-wire circuits, and provides attenuation better than 60 db over the entire band. Three-wire filters measure 23 × 12 × 4½ in. The two-wire filter measures 20 × 8 × 4½ in. Tobe Deutschmann Corp., Filterette Div., Canton, Mass.

Capacitor Mounting Clip

A NEW CAPACITOR-mounting clip that requires no tools for assembly is announced by P. R. Mallory & Co., Inc., Indianapolis, Ind. This clip, originated by Mallory and



made by Prestole Division of the Detroit Harvester Co., Toledo, Ohio, is available in five sizes ranging from ⅝ to 1⅝ in. and is designated as Mallory Type TH or Prestol Series 500.

High-Vacuum Gage

REDESIGNED McLeod type portable high-vacuum gage with built-in

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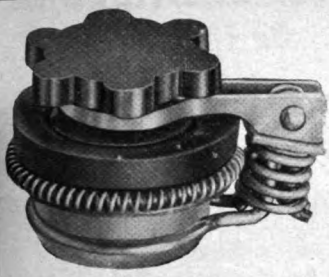

Waterproof Jack Covers

enable jacks to be completely sealed against water and moisture. No special holes or tools required.

Specified on many Navy items. Knob available in black or red. All necessary hardware included. Moderately priced.

Send for catalog on this and other waterproofing items.

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1-3-10-30-100 volts full scale. Peak response, r.m.s. calibration.

HIGH IMPEDANCE—4 megohms at 50 cycles, 60,000 ohms at 100 megacycles. 7 megohms for d-c.

ACCURATE—Better than 2 percent on d-c and 60 cycles thru 50 megacycles.

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Input impedance even greater than probe alone. Flat response from 20 cycles to 200 megacycles. $17.00 net f.o.b. Flushing, N. Y.

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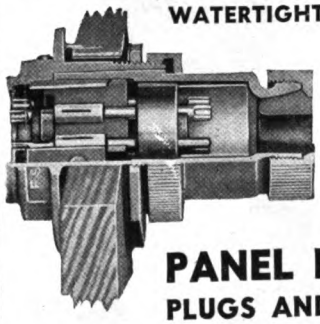

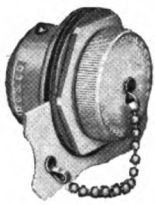

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For locknut or bolted style mounting to panels 1/16" to 5/8" thick. Precision built housings — light weight, ample wiring space.

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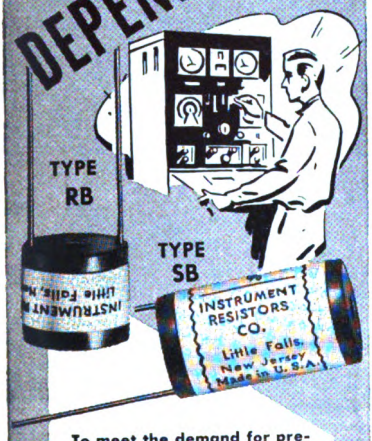

To meet the demand for precision-functioning resistors, impervious to moisture, heat and other detrimental conditions, IN-RES-CO types RB and SB were developed. Non-inductive, and with standard tolerance of ½%, type RB has a maximum resistance of 500,000 ohms, and measures 9/16" high and 9/16" in diameter. It is rated at ½ watt. Type SB is rated at 1 watt, has a maximum resistance of 1 megohm, and is 1 1/16" high and 9/16" in diameter.

Displaying excellent stability under adverse climatic and operating conditions, an additional feature of IN-RES-CO wirewound resistors is their low distributed capacity. The new IN-RES-CO catalog covering the complete line of dependable resistors, meter shunts and multipliers is available. A note on your company letterhead will bring it promptly.

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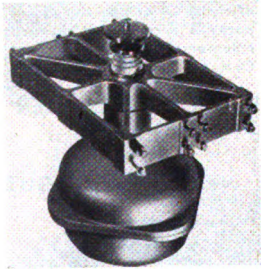
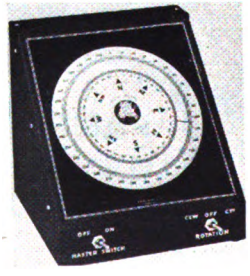
condensable vapor trap is announced by F. J. Stokes Machine Co., Philadelphia 20, Pa. Accurate readings, within the micron range, are obtainable even when condensable vapors are present in the vacuum system. The compact, built-in, renewable chemical cartridge protects the gage by absorbing all such vapors. Other features have been incorporated into the unit which can also be used to check quality of products being processed, to know whether or not a vacuum system is tight and functioning properly, to determine efficiencies of vacuum pumps and other equipment, etc. The unit is available in two models, zero to 5000 microns (5 mm) and zero to 500 microns.

Point-to-Point Communication Unit

ILLUSTRATED ARE the Roto-Beam Rotator (top) and Synchro Anten-





a-Cator station control which will be available postwar to industry from Gordon Specialties Co., 823 S. Wabash Ave., Chicago 5, Ill. Message traffic (voice or code) is directed or beamed over a narrow arc which tends for secrecy, minimizes interference, and increases signal strength 6 to 9 db (power gain of 5 to 8) in the desired direction, without increasing the power of the transmitting source. The unit is effective on either transmission or reception.

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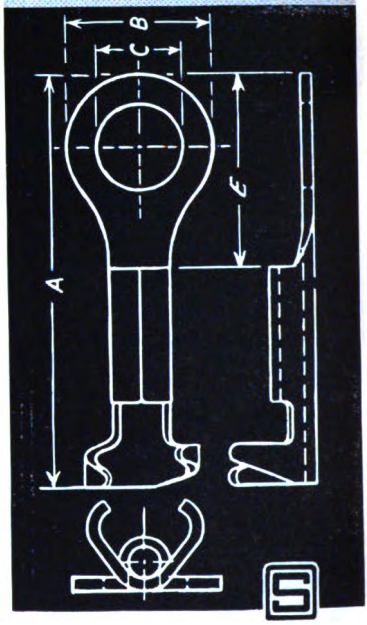
One-Piece
Solderless Terminal



You'll be amazed to see how production can be increased and performance improved, with the Sherman UNI-CRIMP *One-Piece* Solderless Terminal.

Here's a terminal that insures highest conductivity. It is made of fine grain, specially rolled, pure electrolytic copper, rated at 100% conductivity. And — the entire inside of the barrel is serrated, which provides a strong grip on the entire circumference of the wire, and *greatly increases the contact area.*

Write for Bulletin UC-2, giving full specifications. See for yourself why the UNI-CRIMP is stronger mechanically, more efficient electrically, easier to install, and more economical.

Find out how you can switch over to the UNI-CRIMP and speed up production, without any change in your present set-up.

H. B. Sherman Mfg. Co., Battle Creek, Mich.

The Sherman
UNI-CRIMP
Solderless Terminal

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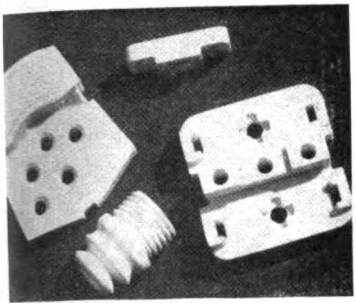

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Properties and Characteristics of Our LAVITE SI-5 Steatite Ceramic Body

Compressive Strength	96,000	lbs. per square inch
Tensile Strength	7,200	lbs. per square inch
Flexural Strength	10,500	lbs. per square inch
Modulus of Rupture	20,000	lbs. per square inch
Dielectric Strength	235	volts per mil
Dielectric Constant	6.42	Frequency of 1 megacycle
Loss Factor	2.90	
Power Factor	446	
Bulk Specific Gravity	2.664%	
Density (from above gravity)	0.096	lbs. per cubic inch
Hardness (Mohr scale)	7.0	
Softening temperature	2,350°F.	
Linear Coefficient of Expansion	8.13x10⁻⁶	
Moisture Absorption (ASTM D-116-42-A)	0.009%	

Makers of electrical and radio apparatus destined for war service are finding in LAVITE the precise qualities called for in their specifications . . . high compressive and dielectric strength, low moisture absorption and resistance to rot, fumes, acids, and high heat. The exceedingly low loss-factor of LAVITE plus its excellent workability makes it ideal for all high frequency applications.

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The Model MK employs the famous Acro switch unit which is your guarantee of millions of trouble-free operations. Write for details—the rugged construction and low cost will please you.

We are able to supply you from stock

General Control Company makes a line of foot switches for every need—ask for Catalog No. 100.

MC MI MF MH

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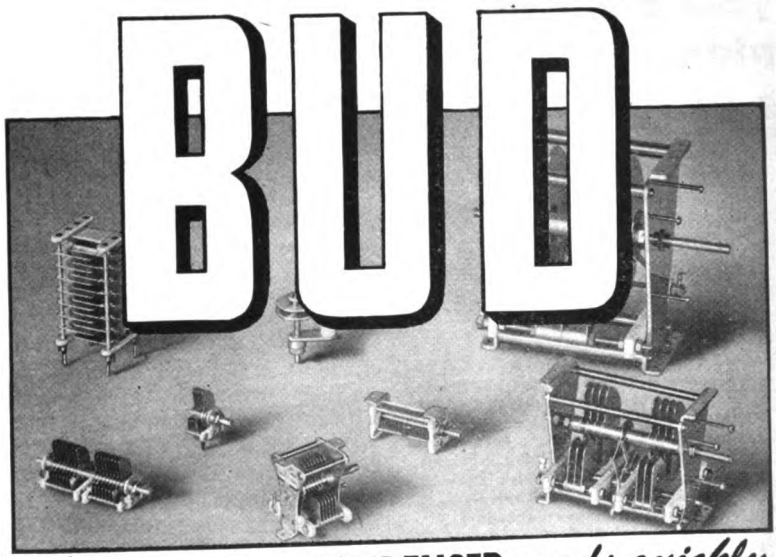
1501 SOLDIERS FIELD ROAD BOSTON 34, MASSACHUSETTS



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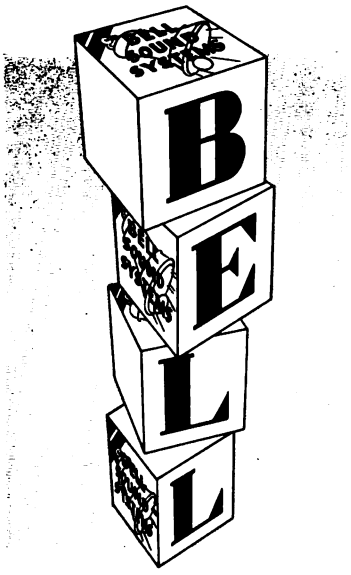

You may want to build BELL electronic controls or assemblies into your post-war plans

BELL may stack up perfectly — in both facilities and experience—as a source of electronic controls or assemblies to meet the needs of your post-war products or production. We'll gladly discuss the ABC's of electronics with you in terms of your specific problem. Why not write today?

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Literature

Symbols for Electronic Diagrams. The Reference Sheet of graphical symbols for electronic diagrams which appeared in August issue is now available in reprint from at a cost of 10 cents each. The reprint is printed on heavier white coated paper and will be mailed flat so that it can be mounted and used as a handy and quick reference sheet. Write Electronics, Editorial Dept., 330 West 42nd St., New York 18, N. Y.

Standards Catalog. Available through American Standards Association (70 East 45th St., New York, N. Y.) is a new list of all American standards and war standards to date. Approximately 800 are listed under various fields covered by the Association and reference is facilitated by a separate alphabetical list. Typical of 1944 items in the electrical engineering category are:

C6.1. Terminal Markings for Electrical Apparatus.

C8.1. Definitions and General Standards for Wire and Cables (AIEE 30-1944).

C16.10. Volume Controls (Home Receiver Replacement Type) (American War Standard).

C29.1. Insulator Tests (AIEE 41-1944).

C39.2. Electrical Indicating Instruments (2½- and 3½-inch round, flush-mounting, panel type) (American War Standard) (2nd edition).

Standards Literature. Two pieces of literature, namely "Standards on Radio Wave Propagation" (definitions of terms relating to guided waves, 1945) and "Standards on Piezoelectric Crystals" (recommented terminology, 1945) are available at 20 cents each from The Institute of Radio Engineers, Inc., 330 West 42nd St., New York 18, N. Y.

Technical Reference Book. This book is a mechanically handy loose-leaf binder which embraces not only the manufacturer's products (United Electronics Company, manufacturers of industrial con-

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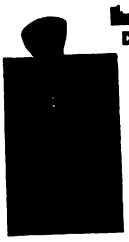

#JE-10—Miniature socket wiring plug for accurate alignment of miniature socket contacts during wiring. Precision cast of zinc base alloy—Pins of stainless steel.

#JE-12 — (Hardened tool steel insert) or JE-13 (Stainless steel insert) Miniature tube pin straightener to obtain a perfect fit when the tube is placed in the set.

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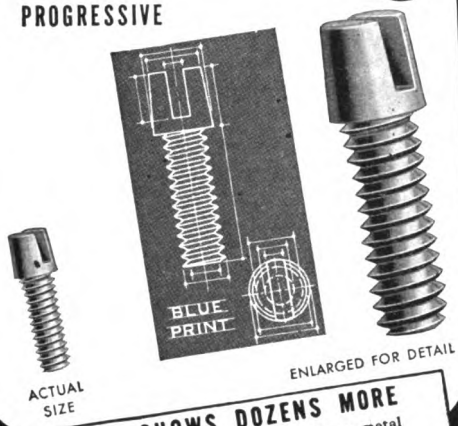

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SENSITIVE • ACCURATE RELIABLE

FOR REMOTE RECORDING INDICATION CONTROL

FUNCTIONS

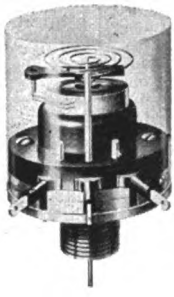
1 Can be directly coupled to low torque indicating meters or movements (existing pressure, temperature gauges, etc.) by simple yoke on instrument pointer without interfering with instrument indicating function.

2 Ideal for take-offs from bellows elements (pressure, temperature, flow, etc.) causing negligible drag on control element.

3 Ideal amplifier follow-up components in bridge-type control—relatively large electrical outputs for small mechanical inputs.

4 Operate directly recorder-controllers, recording galvanometers, milliammeters, oscillographs or polarized relays.

5 Indicate or record remotely positions of shafts, meters, or other mechanical elements.



FEATURES

1 Less than .003 oz. in. input torque.

2 Linearity ½% or better.

3 Weight less than ¾ oz. space envelope 1" x ⅞" cylinder

4 Vibration-proof, 4 to 55 cycles up to 6 g's.

5 2.5 Watts power dissipation.

6 Resistance 100 to 2500 ohms.

7 Jewel bearings, platinum metal brush and resistance material, highest quality contact performance.

8 Long life and dependability proved in many airborne and industrial applications.

9 Available in 270° potentiometer arrangement or continuously rotatable transmitter type—toroidal coil tapped at 120° intervals with twin brush take-offs separated by 180°

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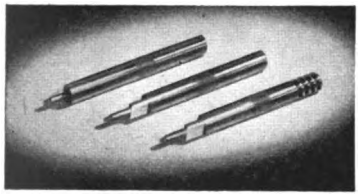
THREE STEPS TOWARD VICTORY



Fast communication between fighting-units gives the all-important coordination that often means the difference between success and failure. These tiny rotor-shafts are a vital part of an Army generator that develops the "juice" to send the messages back and forth.

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trol, radio transmitting and power tubes) but the general field of electronics. Among some of the chapters contained in the book are: "Basic theory of electron tubes; tube classifications and characteristics; tube manufacturing procedure; tube functions and modes of operation; circuit data; end uses of electron tubes; installation considerations; standardization practice; interchangeability chart; definitions of electrical terms; new standardized circuit symbols; conversion tables and a bibliography. Write United Electronics at 42 Spring St., Newark 2, N. J.

Speaker. A two-way multi-cellular loudspeaker (designated as The Duplex Speaker) for monitoring, radio, public address, recording, television and f-m reproduction, is illustrated and thoroughly described in a 12-page bulletin. The bulletin also contains a sound chart which shows the frequency coverage (from 40 to 15,000 cycles plus) of the speaker. Response curves for Model No. 605 Duplex loudspeaker are also given. Altec Lansing Corp., 1210 Taft Bldg., Hollywood 28, Calif.

Electrical Contacts. A new 36-page electrical contact catalog and data book designated as Contact Catalog No. 12 is published for manufacturers of products utilizing contacts. Many types of Stackpole contact materials and notes on the applications of each type is given. Stackpole Carbon Co., St. Marys, Pa.

Aircraft Communications Equipment. Type RTA-1B communications equipment for aircraft use combines ten crystal-controlled receiver and transmitter channels with integral power supplies into a single unit weighing less than 88 lb. The equipment is described in a 4-page bulletin from Bendix Radio, Baltimore 4, Md.

Magnavox Literature. Four separate pieces of literature from The Magnavox Company (Fort Wayne 4, Ind.) include: "A Reference Guide to Magnavox Electrolytic Capacitors" which is a 24-page booklet; and three single sheets which

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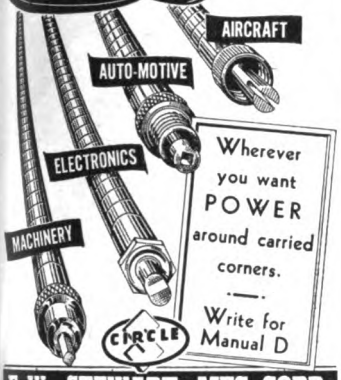

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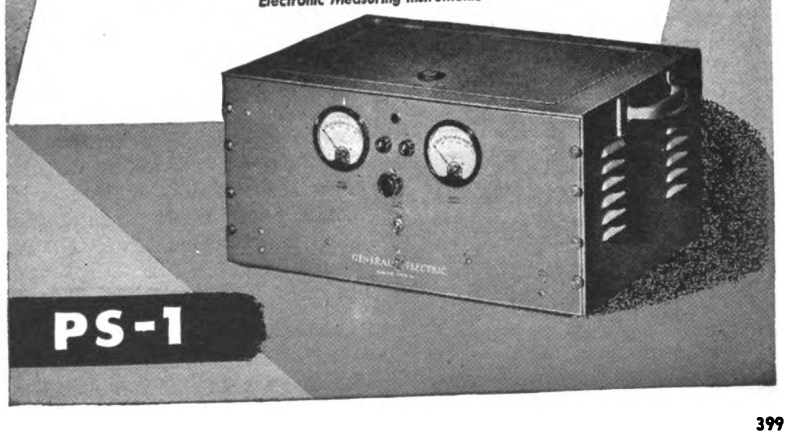

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describe Model 14-12C, Model 12C and Model 305 (15-in.) dynamic speakers.

Ingot Iron. Advantages of ingot iron are given in a 24-page booklet entitled "ARMCO Magnetic Ingot Iron for D-C Applications." The iron is described as a dense, highly refined open-hearth iron with high conducting powers. The American Rolling Mill Co., Middletown, Ohio.

Headers and Sealed Leads. Data and specifications on E-I multiple headers and sealed leads are contained in a 6-page leaflet. Four basic types of hermetically-sealed headers are described in diagram form as well as in descriptive data. One page of the leaflet is devoted to hermetically-sealed terminals. Electrical Industries, Inc., 42 Summer Ave., Newark 5, N. J.

Nilsson Electrical Laboratories. Instrument manufacturing and service facilities of Nilsson are described in a 20-page booklet which also illustrates and describes some of the products (shunts and resistors, radio direction finders, audio amplifiers, vibration test table, etc) which Nilsson furnishes. 103 Lafayette St., New York 13, N. Y.

High-Vacuum Pumps. Improved Microvac pumps (with higher volumetric efficiencies and lower power requirements, and greater simplicity, than the models they replace) are described in a 4-page bulletin (No. 463) from F. J. Stokes Machine Co., Tabor Road, Philadelphia 20, Pa.

Vinson's Quarterly Report. The Director of War Mobilization and Reconversion has made his Quarterly Report (dated July 1, 1945) to the President, the Senate and the House of Representatives. It bears the title of "The Road to Tokyo and Beyond" and is available from the Division of Public Inquiries, Office of War Information, 1400 Pennsylvania Ave., N. W., Washington 26, D. C.

Bendix Radio Literature. Loose-leaf sheets issued by Bendix Radio, Baltimore, Md., include Bulletin

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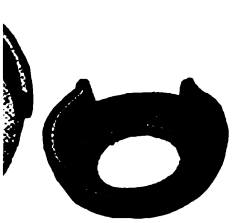

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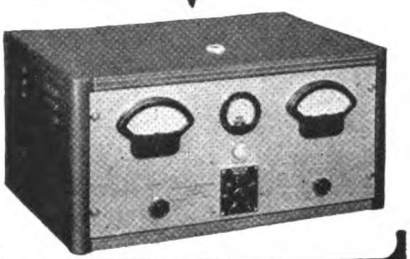

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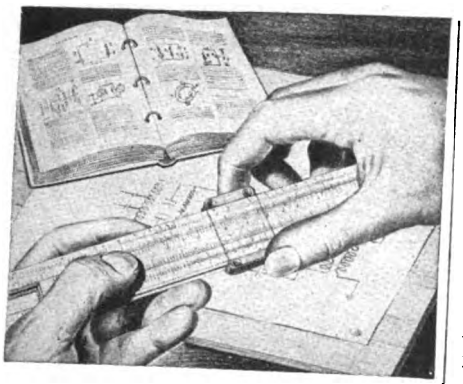

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No. SE-110 which describes Type MS-97 control desk for the master control position of a radio communication station handling a heavy volume of traffic; Bulletin No. SE-112 which describes Type MS-105A broad band dipole antenna, especially suited to aeronautical service operating in the range of 108 to 132 mc; and a 1-page leaflet on Type MT-48X antenna strain insulator.

Dial Light Sockets. Catalog No. 101 contains 16 pages of illustrations and some descriptive data about dial light sockets for radio receivers and transmitters, test instruments and other electrical equipment. Lenz Electric Mfg. Co., 1751 N. Western Ave., Chicago 47, Ill.

Microphone. Model BA-301 "Hushatone" is a miniature speaker designed for under-pillow use. A locse-leaf sheet from The Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio, illustrates and describes the microphone.

Cathode-Ray Photography. A comparison of the essential characteristics of P-5 (calcium tungstate) and P-11 (sulphide) screens for cathode-ray photography are contained in a 1-page bulletin from Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J. Both screens are of the short persistence, blue fluorescent type and of high photographic actinity, the main difference being the considerably higher photographic and visual efficiency of the P-11 screen and the shorter persistence of the P-5 screen.

Rotary Power Equipment. Bulletin No. 445 is new and condensed and describes various generators, magmotors, converters and dynamotors manufactured by Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill.

Hermetically-Sealed Instruments. A 4-page bulletin illustrates and describes 1½, 2½ and 3½-in. hermetically sealed instruments for panel flush mounting. The Triplett Electrical Instrument Co., Bluffton, Ohio.

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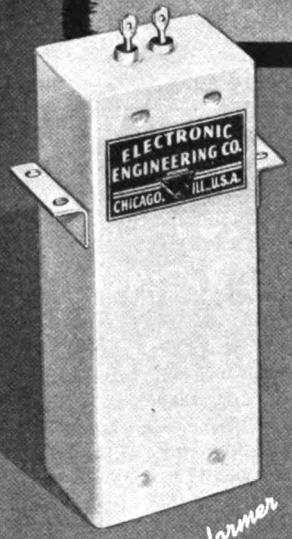

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NEW BOOKS

Cavity Resonators

By ALFRED DE QUERVAIN. Electrische Schwingtöpfe und ihre Anwendung in der Ultrakurzwellen-Verstärkertechnik (Electric "Pot" Resonators and their Application in Ultra Short Wave Amplifiers). *Published by A. G. Leemann & Co., Zurich, Switzerland, 1944, 86 pages, Fr. 6. —, RM 3.60.*

THIS SMALL German-language volume is an account of the author's work during the past few years on the theory and application of certain forms of cavity resonators to uhf amplifiers.

Although many variations are covered in the text, the fundamental form of resonator considered consists of an enclosed coaxial line cavity with capacitance loading at one end provided by a large disc on the central conductor, all dimensions being small in comparison with the resonant wavelength. Such cavities are designated by the author as "pot" resonators.

By treating these resonators as consisting of lumped inductance and capacitance, a graph is shown in which dissipative loss is plotted as a function of cavity dimensions for a series of reference cavities constructed of copper and for a given frequency and inductance. Since the values for unloaded Q and for parallel impedance are readily obtainable from the dissipative loss, cavities of any desired characteristics, within attainable limits, are easily proportioned by scaling the dimensions of a suitably chosen reference cavity from the graph. Although the resonators discussed throughout the book are for the range from 150 to 300 Mc, dimensions may be scaled down to the microwave range or up to the lower-frequency spectrum. An analysis of the temperature coefficient of frequency is given and a first-order method of temperature compensation is derived which consists of making the central conductor of two differing materials, having appropriately selected lengths and temperature coefficients.

Taking into account the well-known limitations of conventional tubes at these frequencies, the application of resonators as interstage coupling networks is thoroughly analyzed and a brief discussion of

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coupling to generators and loads (receiving and transmitting antennas) is included.

Band-pass filters as interstage coupling networks, both theoretically and as applied to pot resonators, are treated in some detail. The capacitance-coupled band-pass filter is achieved by placing the resonators together with a common end-wall. The end-wall is pierced by an aperture permitting direct capacitance coupling between the two end-loading discs of the resonators. From measurements on an enlarged model, data is given in the form of a graph from which the coupling capacitance can be directly determined. Inductive coupling between the band-pass elements is obtained by employing as the common end-wall the short-circuiting sections of the resonators and providing the end-wall with apertures. Experimental data is given as an aid in determining the inductive coupling. This form of coupled resonator construction lends itself to a clean-cut mechanical layout since the tubes can be mounted between resonator pairs.

An adjustable magnetically coupled resonator pair is described in which a rotating element permits adjustment of the coupling apertures. Variations of resonators employed as four-terminal matching networks are briefly discussed.

The remainder of the book is devoted to a discussion of measurement apparatus and data together with a discussion of results. Data are given on Q measurement, capacitance and inductively coupled filters and including some information on the measurement of metallized resistors. It seems quite likely that the application of such resonators to the precision measurement of resistance and of the dielectric properties of materials in the uhf region will assume considerable importance.

Finally, a two-stage pentode amplifier utilizing a band-pass filter consisting of three inductively coupled resonator sections is discussed in detail. Mechanical design is shown and performance characteristics are given which satisfactorily confirm the theoretical treatment presented in the text. A bibliography of both American and continental sources covers the field.

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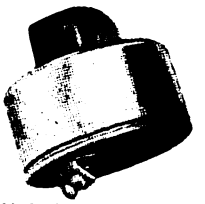

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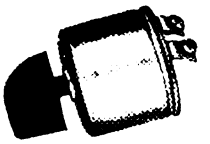

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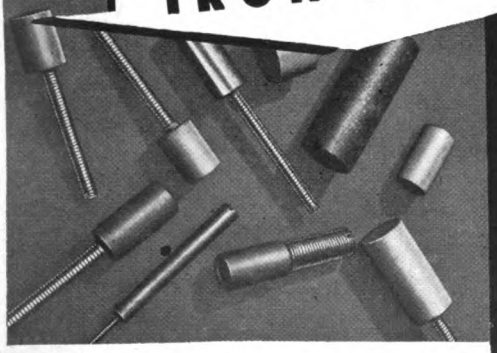

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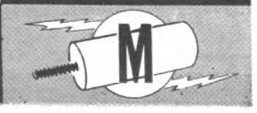

lumped-parameter circuit theory point of view, the material in the book is clearly presented and it should prove of interest to engineers designing equipment and to those engaged in measurements in this general frequency range.—H.H.

• • •

Television Programming and Production

By RICHARD HUBBELL. *Published by Murray Hill Publications, Inc., New York, 1945, 207 pages, $3.00.*

TELEVISION HAS long needed an evaluated summary of its programming experiments. Within limits this book fills that need. Unfortunately, the title promises more than the text gives. It deals with production methods (excepting remote pickups), but fails to discuss types of programs, a study important because successful televising of some subjects will require equipment (and studios) not yet designed.

By way of introduction to a theory of video technique, television is compared with allied arts. The notes on video broadcasting vs. the theater or the motion picture are a scrambled rehash of social, economic, and artistic aspects of drama and film, contributing no new conclusions toward the development of a television art. When discussing radio and television, the author is more at home. Part Five: "The Audio" is likewise provocative.

The kernel of the production recommended is an appeal for greater camera mobility patterned after current motion picture equipment. "Since television can not equal the tempo of film cutting but can exceed the mobility of the motion-picture camera, it seems that a promising field of development is to be found in this characteristic."

The reviewer can not agree with this basic assumption. Television can match the rhythm patterns of film technique providing improvements are made in camera design—smaller size, less weight, greater sensitivity—so that greater numbers can be employed. Greater camera mobility seems to be an undesirable path for television to follow because it would increase the complexity of production,

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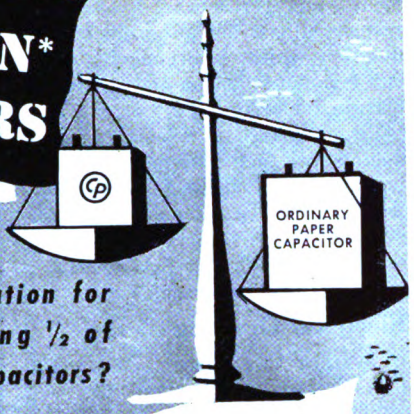

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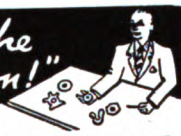

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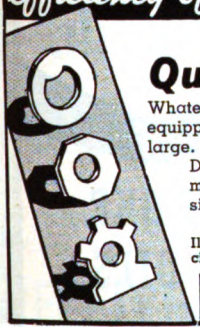

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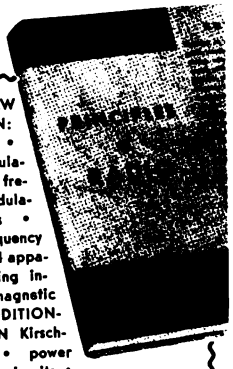

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physically and in staff requirements, and further subdivide the responsibilities for program coordination which, even under present techniques, make too great a margin for error.

Readers fresh to television production will find much information in this initial study of the subject. It will be interesting, however, to receive reports from other experimenters in this field.—V.M.B.

• • •

Electrical Drafting

D. WALTER VAN GIESON. *McGraw-Hill Book Co., New York 18, N. Y., 140 pages, $1.50.*

KNOWLEDGE OF WIRING PLANS and the methods of their development is a valuable asset to the engineer or draftsman entering the electrical profession. Yet the technique of this special field of drafting has received slight attention in the conventional teaching of drafting. To fill this void and to acquaint the student with the procedure followed in the preparation of wiring and circuit drawings, the author has assembled typical examples of electrical installation drawings which are used in many fields.

This is not a book dealing with the use of drafting instruments; the author assumes that the student has had previous training in that manual art. This pioneering volume explores and discusses, through the analysis of practical problems, the special drafting technique used in the preparation of electric circuit diagrams and wiring plans. At first glance, because of the short chapters, it might appear that the treatment is too brief. But, considered from the standpoint of an overall coverage of fundamentals and practical procedure, the text is adequate as a basis for an excellent course in the subject.

Much theory is included in the presentation of the several divisions of the electrical equipment and installation field. Following a discussion of symbols, schematic sketches and finished circuit drawings, the author interprets wiring diagrams as used for many purposes.

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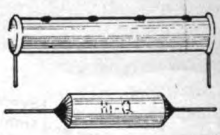

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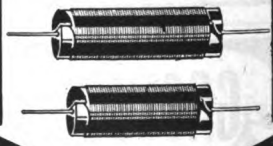

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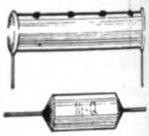

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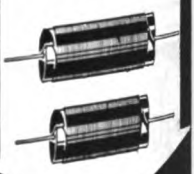

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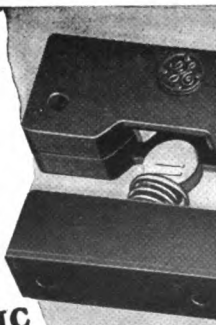

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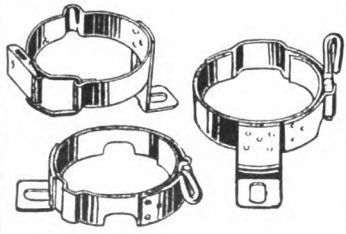

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Automatic Telephone Practice

HARRY E. HERSHEY. *Technical Publications, Whitewater, Kansas. Advance printing of Part C—Circuit Kinks—from Fifth Edition, 1945, 24 pages, $1.00.*

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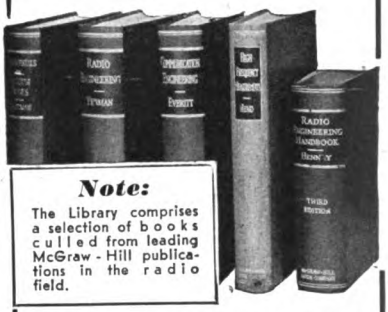

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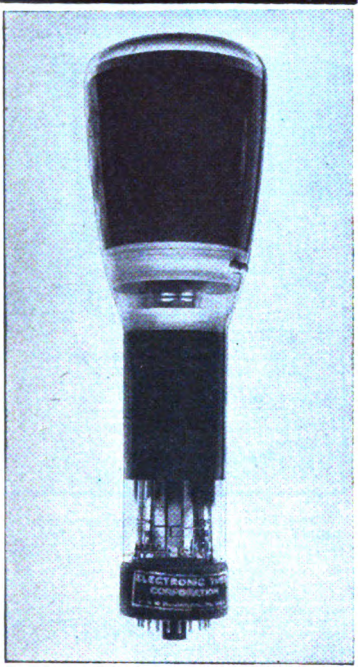

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By BARBARA ELNA BENSON. *McGraw-Hill Book Co., New York 18, N. Y., 124 pages, $1.50.*

THE USE OF MUSIC as a morale-building instrument in industrial plants to cushion the slumps in efficiency of workers has had a tremendous spurt during the war. This book is a concise treatment of present-day practices with respect to the use of music in industry. It is divided into five chapters—The Organization of an Industrial Broadcasting System, Programming Music for Industry, Broadcasting for Industry, Scientific Research on Music in Industry and The Evolution of Industrial Broadcasting and Conclusions. There is also an excellent bibliography on the subject and a lengthy list of record titles with indications of the various times during the day for which each is best suited. There is no formal discussion of equipment used as such, but comments scattered throughout the book point out the advantages and limitations of different kinds of systems.—K.S.P.

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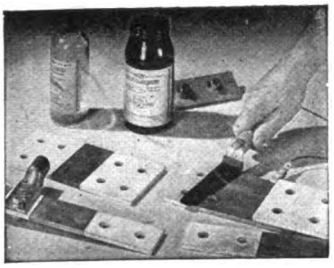

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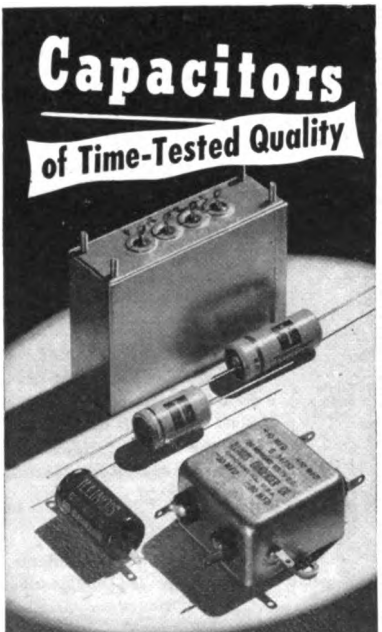

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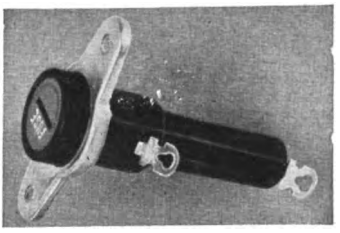

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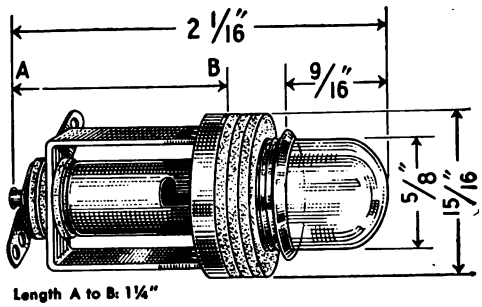

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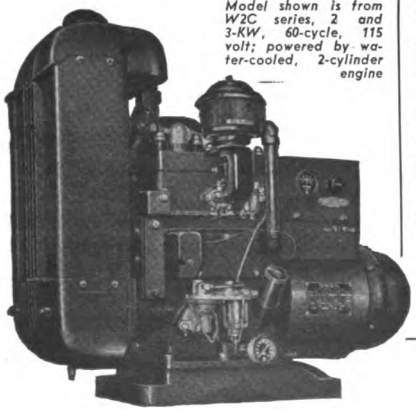

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Signal Level

Gentlemen:

Mr. Charles E. Gardiner, in the Backtalk department of the June issue of ELECTRONICS, suggests the symbols $\frac{1\text{ v}}{100\text{ db}}$ and $\frac{30\text{ db}}{1\text{ w}}$ to represent 100 db below 1 volt and 30 db above 1 watt. Without any explanation of symbolism, the usual practice is that the numerator be read first, which would make the former appear to be 1 volt above 100 db. I would suggest, instead, 100 db\1 v and 30 db/1 w— in other words, \ for "below" and / for "above." No hardship on Mergenthaler, either.

B. HARA
New York, N. Y.

• • •

Pickup Terminology

Gentlemen:

THE OBJECT of this letter is to call your attention to an error in your June 1945 issue, page 108, Moving-Coil Pickup Design.

Whether a moving conductor cuts the flux lines, or the flux lines cut a stationary conductor is of no consequence, so long as the final results are what is desired. It is specifically the writer's wish not to go into any discussion of the merits or demerits of the general structure of the device in question. However, as described, the device is actually a "moving inductor" type, and the voltage generated in the coil is due to variation in reluctance between the magnet poles and the vibrating steel tube—or armature.

As a matter of fact, the vibrating mass would be much lower and the results better, if the coil were stationary and not carried by the moving steel tube. To the writer, it appears that originally, the coil was wound on an aluminum tube, in which case the reluctance in the gap was fixed and in that case, the vibrating coil would cut the flux. However, because the resultant out-

(*Continued on page* 424)

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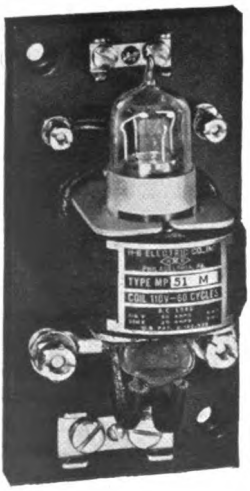

put this RELAY to work with electronic tubes

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THERMO-REGULATORS • HYDROMETERS

(*Continued from page* 416)

put was much too low, the steel tube was then added. This, of course, increased the output as a result of variation of the reluctance in the gap.

N. PAYNE
New York, N. Y.

Dear Mr. Payne:

I can easily understand how you might get the impression of a moving inductor after reading the article. The coil wound on the sleeve rocks through a very small angle on its own center so that any magneto-inductive action of the sleeve essentially cancels out.

In other words, if it were possible to support the coil in its present position and rock the stylus and sleeve only, little output would result, as the top half of the sleeve would approach slightly say, the North pole, and its effect of changing the reluctance of the gap would be nearly cancelled by the corresponding opposite motion of the bottom half of the sleeve.

The only real reason for using the sleeve is to raise the flux in the gap and concentrate the flux lines through the sides of the coil. Further, if this device relied upon an armature of the type Mr. Payne has in mind, its performance would depend upon the linearity of the metal used. In this case the sleeve is actually saturated at all times and the output remains as that of a moving coil except for the considerable increase in efficiency as a result of the intensified and controlled gap.

T. W. LINDENBERG
Fairchild Camera & Instrument Corp.
Jamaica, N. Y.

● ● ●

Radar on Iwo Jima

U. S. Army men place sandbags around a truck containing plane-detection equipment used in conjunction with antiaircraft guns on Iwo Jima

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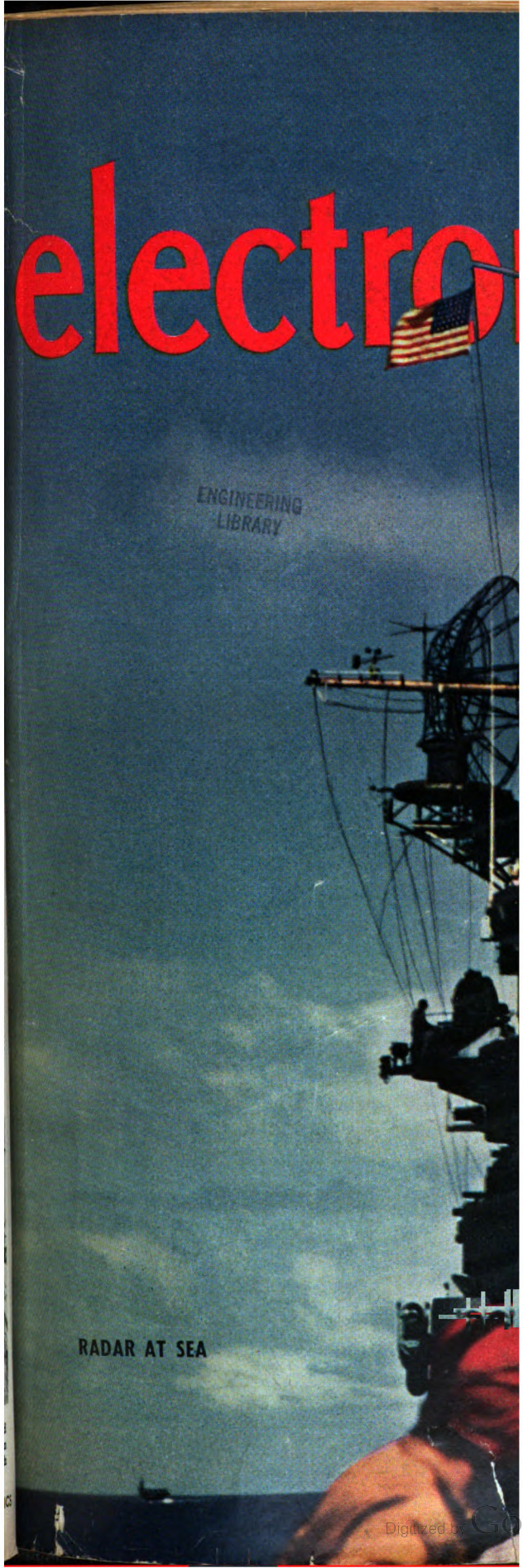

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Amperex Type 889-R Transmitting Tube. Filament voltage, 11 volts. Filament current, 125 amperes. Amplification factor, 21. Direct interelectrode capacitance: grid to plate, 20.7 μμf; grid to filament, 19.5 μμf; plate to filament, 2.5 μμf. List price, $325.00.

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electronics

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OCTOBER • 1945

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CROSS TALK

▶DGF . . . As of September 1, Mr. Donald G. Fink, a member of the editorial Staff of ELECTRONICS since 1934, but on leave of absence for the last four years, returns to the staff as Executive Editor. A graduate of MIT, Mr. Fink spent a year in graduate study before joining ELECTRONICS. While Managing Editor, he was "loaned" in May 1941 to the Radiation Laboratory shortly after its formation and was assigned to a group working under Melville Eastham (General Radio Company) which developed the Loran system of long-range navigation which now covers most of the globe with electronic lines of position for the navigation of ships and aircraft. The Loran transmitters now in world-wide use are based on his designs.

During his work at the Radiation Laboratory he wrote the first radar textbook, "Microwave Radar", for use of the laboratory staff and military personnel. Early in 1943 he was appointed head of the Loran division of the Laboratory and later went to England and to Africa to initiate the installation of Loran equipment for the guidance of bombers over Germany. After the conclusion of this work he transferred to the office of Dr. E. L. Bowles in Washington where, as Expert Consultant in the Office of the Secretary of War, he advised the Army Air Forces concerning the use of Loran and related navigational devices. In the winter of 1943-44 he traveled the Pacific as far as Western Australia exploring for sites for the Loran stations in that part of the world. In his air travels from Darwin to Cairo he has covered some 75,000 miles.

With Loran well under way, Mr. Fink was assigned by Dr. Bowles to the headquarters of the Ground Forces to advise on the use of radar for ground force application, particularly gunfire control and the detection of ground targets by radar. At the same time he was appointed a member of the Committee on Air Navigation and Traffic Control, a group of civilian consultants who have been advising General Arnold on the long-term uses of radar and communication to the Army Air Forces.

Mr. Fink will retain his membership on this important committee. As Executive Editor he will share with Keith Henney the responsibility for the editorial direction of ELECTRONICS and, of course, will maintain and extend his acquaintance with the industry. At the same time he will continue to serve the Government in ways which his four years "on leave" have so particularly fitted him.

▶PATENTS . . . An agenda listing the topics under study by President Truman's committee on the patent system has been made public by William H. Davis, Director of Economic Stabilization, and chairman of the committee. The committee set up by Secretary Wallace is made up of Mr. Davis, Tom C. Clark, Attorney General, Dr. Vannevar Bush of OSRD and C. F. Kettering, Chairman of the National Patent Planning Commission.

The subjects for consideration by the committee fall into four groups:

1. What action should be taken to prevent the issue of patents that are not for true inventions.
2. What action should be taken to make patent protection for true inventions more simple and effective.
3. What action should be taken to prevent abuse of patent rights.
4. A re-examination of the scope of the patent system in the light of the constitutional objective to promote the progress of science and useful arts.

In making public the agenda, the Committee hopes that interested persons will express their views on the subjects to be examined and that these persons will communicate their views to the Secretary of Commerce.

▶RATS . . . The story of the pied piper of Hamlin, who got rid of rats by tootling on a flute, seems to have a modern counterpart in a Spokane electronics engineer. He is about to rid the county courthouse of pigeons by use of a supersonic whistle which, though "four times too high to be detected by human ears is extremely irritating to pigeons."

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RADAR

FIG. 1—The radiator of this British CH early warning station is of the mattress-type, supported on 360-foot steel towers. Since 1938 these ponderous stations have guarded the English coast against invading aircraft

IT IS BY NOW no secret to the readers of ELECTRONICS that radar contributed more toward winning the war than any other technical device of recent advent, save only the atomic bomb. The head of our largest radar laboratory has drawn a nice comparison in saying: "The atomic bomb finished the war. Radar fought it."

Nor are the uses of radar in warfare any longer a mystery; the popular press has seen to it that everyone who can read knows about radar blind bombing, radar gunfire control, radar warning of approaching aircraft. To this great story there is little, in broad outline, that the editors can add.

But much remains to be added in filling in the essential technical background. With the lifting of censorship a steady stream of such technical material will now be forthcoming in these pages, including discussion of basic factors underlying operation and design, descriptions of radar gear, and analysis of circuits and components in the light of future applications. Meanwhile this report on the uses of radar in war is presented.

Radar got its start, both here and abroad, as a device to detect the approach of enemy aircraft. The first radars used operationally were the CH (chain home) stations along the English channel coast (see Fig. 1), which went into regular operation in 1938. These low-frequency (about 25 mc) units were successful in detecting enemy bombers forming over airfields in France and in tracking them in over the coast. Meanwhile, fighters and fighter-control radar stations were alerted to meet them. Similarly, one of the first American radars was the SCR-270, operating on approximately 110 mc, which detected unidentified aircraft approaching Pearl Harbor on December 7, 1941 at a distance of 132 miles.

As the war progressed the need for early warning continued unabated and newer equipments, working on higher frequencies, were produced. The size was reduced so that the entire gear could be carried by men storming a beachhead (Fig. 2). As a result of wide-

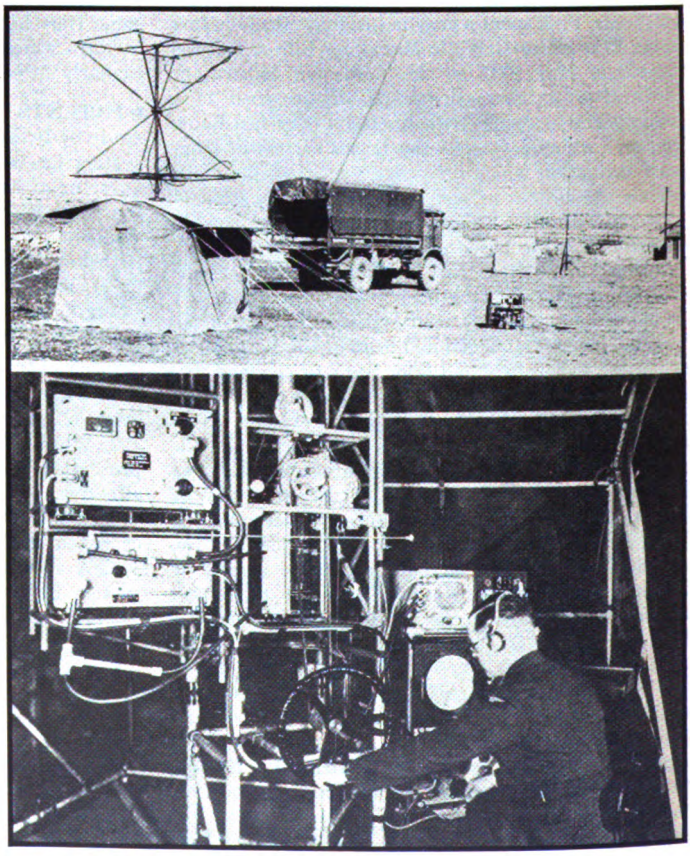

FIG. 2—British LW (light warning) radar, similar to the American SCR-602. It serves the same purpose as the CH station but is man-portable. Four Yagi antennas are used, each consisting of a reflector, a folded dipole, and four directors. It can be set up and operating two hours after arrival at the site

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WARFARE

The technical factors behind the uses of radar for warning and surveillance of enemy activity; to control guns, searchlights and bombs; for navigation of ships and aircraft

spread installation of this warning gear, virtually all ships and aircraft which approached the shores of Great Britain, Africa and the Continent, America and the outposts of the Pacific war, were tracked by radar.

Technically, the problem of early warning by radar resolves itself into certain definite requirements. First, since it is necessary to detect the oncoming aircraft at the greatest possible distance, the power of the transmitters and the sensitivity of the receivers must be the highest obtainable. By high power is meant not only high peak power in the transmitted pulses, but also high energy in each pulse. This is achieved by using pulses of considerable length, as long as 20 or 30 microseconds in some cases. Such long pulses have the disadvantage of blocking the receiving system for a correspondingly long time, so that very nearby targets, within a few miles, are not detectable. But since the purpose was long-range detection this was not considered an objection.

A second requirement for early warning by radar is widespread coverage of the area from which airplanes might come. Such coverage is obtained either by use of a wide beam, moved slowly over the suspected area, or a narrow beam moved correspondingly faster. Beams as wide as 30 degrees were used at first. But in the interest of increasing the power density within the beam, narrower beams, involving higher frequency radiation, were introduced.

Finally, and most important, is the requirement of complete coverage, without gaps through which the enemy can sneak undetected. The cause of such gaps is the presence of reflections from the ground

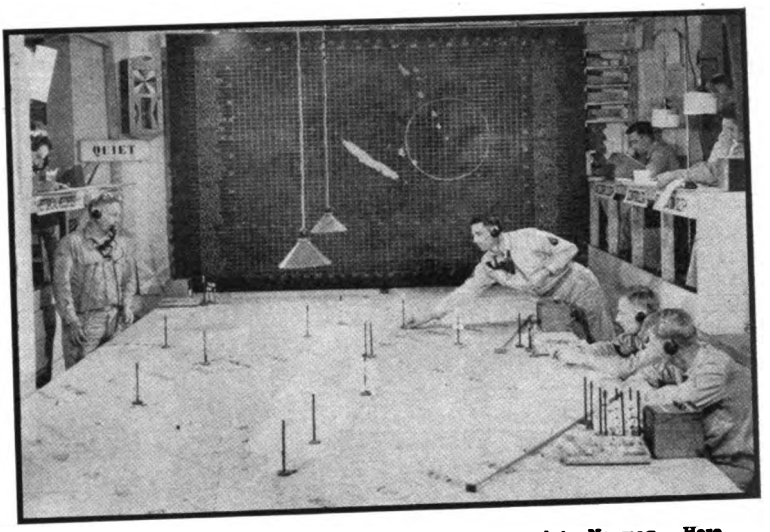

FIG. 3—The plotting board of the 1st Island Command in Noumea. Here position reports of aircraft detected by many scattered radars are coordinated and the progress of unidentified units followed by moving the red-like structures, each one of which represents an aircraft

FIG. 4—A microwave search and warning radar on a PT boat. The dome structure houses the revolving parabolic reflector, or dish. Such radars were useful not only to warn of nearby air and surface units, but permitted accurate navigation among blacked-out ships and inside enemy harbors

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or the surface of the sea. The reflected rays, combining with the direct rays, produce a many-lobed coverage diagram, the gaps in which constituted a serious shortcoming of the early equipment. The most serious gap was that existing close to the ground; to take advantage of this, both Germans and Japanese soon learned to approach less than 100 feet above the terrain. The solution was, again, in the use of higher frequencies and narrower beams. The high frequency increases the number of lobes and so narrows the gaps between them. Moreover, the narrower beams of the high frequency gear reduce the amount of signal transmitted toward the ground, so the effect of reflections was cut down or eliminated entirely.

The detection of the enemy is of little value unless something can be done about it. The first step is to collect target information from a number of radar stations which report into a central plotting room (Fig. 3), where tracks of all targets are kept. The telephonic communication required for such activities is complex, and it must be surefire. The same function is carried out aboard ship, in the Combat Information Center, a plotting room which receives target data from all radars aboard and even from radars of nearby fleet units. Even PT boats (Fig. 4), carried warning radar.

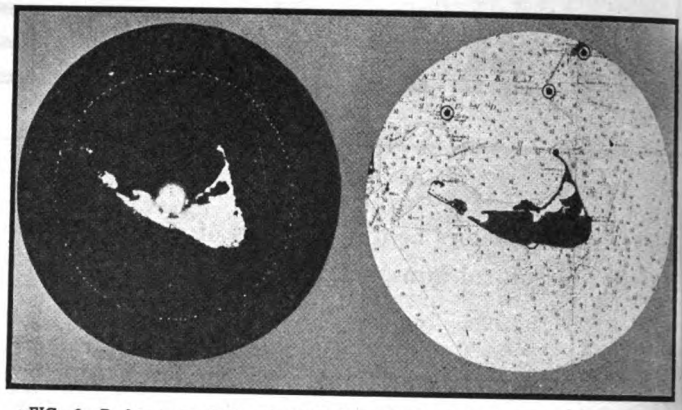

FIG. 6—Radar map (left), of Nantucket Island photographed from the PPI indicator of an airborne radar. The bright spot at the center indicates the position of the aircraft. The circle is a distance calibration, produced by the range circuit of the radar to indicate the distance scale. At the right, for comparison, is a map of the island

Since the best way to attack an airplane is to go after it in another airplane, it was natural that the next extension of early warning radar should be control of fighters and fighter-bombers. The technique, developed in England in 1940-41, is known as GCI (Ground Control of Interception) and AI (Airborne Interception). In GCI, the radar operator on the ground observes echoes from the enemy aircraft and the opposing fighter, on the same indicator screen. Instructions are radioed to the fighter pilot to indicate the height and direction of the enemy aircraft. As the fighter closes in, he is controlled until he reports visual contact and begins the attack.

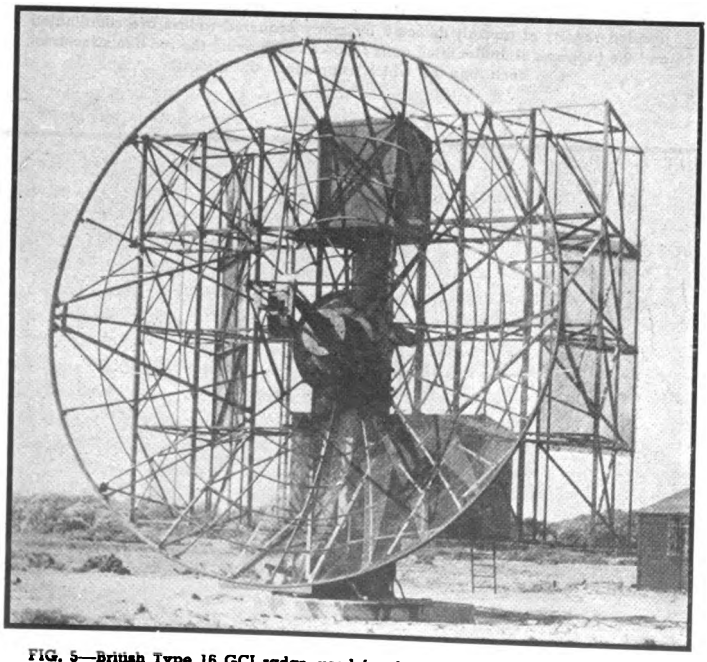

FIG. 5—British Type 16 GCI radar, used for the control of aircraft in offensive operations. The parabolic reflector is composed of a wire mesh, the holes in which are considerable smaller than a wavelength and hence essentially opaque to the radiated signal

GCI and AI—Partners of Early Warning

This technique was outstandingly successful during the German daylight attacks; in one day 185 bombers out of 500 attacking were destroyed, largely through radar detection of enemy planes and guidance of our pilots.

Success in this technique requires fairly accurate knowledge of the height of both defending and attacking aircraft, information not supplied by the early-warning radars. Several height-finding methods were developed, the most elementary depending simply on the strength of the radar echo observed at a given range (that is, by a calibration of the contour of the beam). A more elaborate method used a narrow beam radiator which could be swung upward and thus measured the elevation angle, as well as the range, of the target. A

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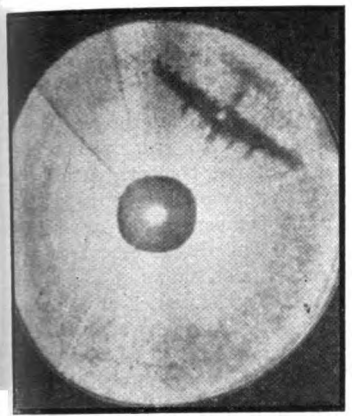

FIG. 7—Radar shadow picture. As a friendly bomber flew underneath an airborne radar, it intercepted the radar signal and thereby cast its shadow on the ground

typical GCI station (of a type used largely for offensive operations late in the war) is shown in Fig. 5.

When the Germans, balked during daylight, switched to night operations, visual contact was less easy to achieve. So GCI was supplemented by airborne radar which would permit the fighter to see the enemy aircraft regardless of visibility conditions. Here the technical obstacles were formidable. Total equipment weight had to be reduced to a few hundred pounds at most, and the radiator size was so limited that a narrow beam (necessary for precise determination of the enemy aircraft's position) could hardly be achieved with the low frequencies feasible for ground applications.

The need for better AI gear gave powerful impetus to the development of microwave radar. In 1940, a practical source of high-power pulses at frequencies of the order of 3000 mc was developed at the University of Birmingham. This was the cavity magnetron, the details of which are still under wraps at the time of writing. But it can be said that this device is one of the basic inventions of the radio art, an improvement in principle as well as in degree over all previous forms of magnetron. The magnetron was brought to America in August of that year and copies hastily produced by the Bell Telephone Laboratories.

On this basic item was founded the research program of the Radiation Laboratory at M.I.T., which has since been the principal source of microwave radar development. This Laboratory, now so well-known to the electronics industry, started with less than 50 people and grew to over 3800 by the end of the war. Radiation Laboratory solved the AI problem and went on to other, even more important applications of microwaves.

The microwave technique, developed to solve the AI problem, brought with it the need for all manner of r-f components, particularly r-f mixers, duplex switching gear (t-r box), r-f plumbing of every possible description, rotating joints in waveguides and coaxial lines, new forms of radiators and reflectors, in fact a whole new art. The success of the effort is well known. Basic designs of microwave radar for the Allies originated at Rad Lab and were put into production by the electronics industry of America to the value of well over two billion dollars. As of July 1st, 1945, the U. S. Army and Navy alone, not counting supplies to the British, had accepted delivery of 2.7 billion dollars worth of radar, most of it microwave, and nearly half of it for airborne use.

During the development of the GCI technique, another basic invention made its appearance. This is the Plan Position Indicator (PPI) which makes it possible to view many targets simultaneously. In the PPI, the cathode ray spot starts its motion from the center of the screen, and moves outward at constant speed in the radial direction. The direction of the radial deflection is tied in with the direction of the radiated beam, and the distance from the center of the tube is proportional to the time interval between transmission of each pulse and the reception of the echo. As the beam rotates the phosphor retains the image for as long as several minutes. The PPI thus paints a picture on the cathode-ray screen which is a plan view of the territory surrounding the radar. The bias of the cathode-ray tube is normally set so that the beam is dark. When an echo is received from a target, the spot is brightened momentarily. This light represents the distance and direction of the target relative to the radar.

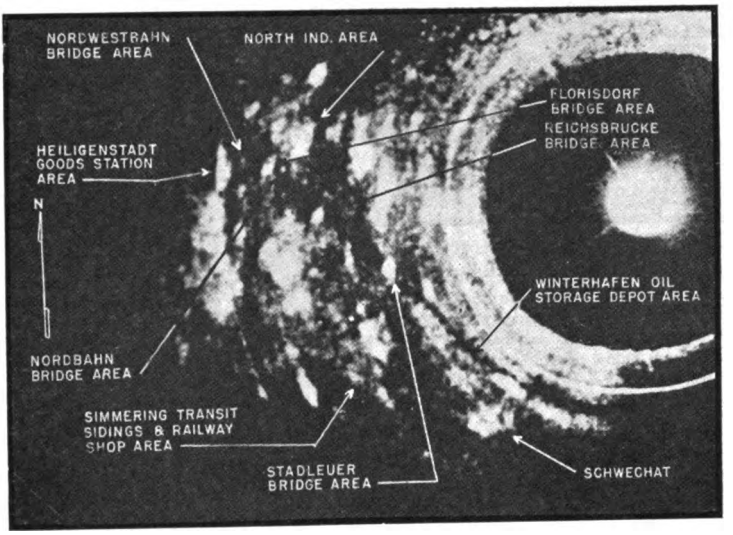

FIG. 8—The area around Vienna, as it appears on the scope of a radar bombsight. Extensive training, including comparison with reconnaissance photographs, is necessary before such PPI pictures can be interpreted with sufficient accuracy to permit blind bombing of the targets indicated

PPI—Navigation and Bombing by Terrain Echoes

At first PPI was used simply to indicate aircraft targets. But it soon became evident that echoes from the features of the surrounding terrain would give rise to a

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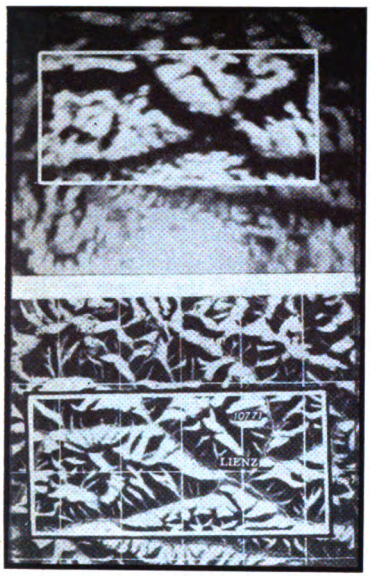

FIG. 9—Radar relief map, obtained over mountainous territory in the Austrian Alps. This PPI picture (top) shows bright surfaces on the near side of the mountains, dark shadows beyond. The relief map below provides a comparison

radar map, which could serve as a navigational aid.

Behind the PPI picture are a number of interesting technical factors. First it must be realized that the map is a true representation of the earth's surface only when the radar is situated on the ground or aboard ship. When the radar is airborne, the distance represented on the c-r tube is the so-called slant-range, or the distance from aircraft to target, and not the distance along the surface of the earth. This distortion can be compensated, of course, by adjusting the rate of radial deflection in accordance with the height of the aircraft. The detail visible in a PPI map is determined by the size of the radar beam relative to the terrain features. In Fig. 6, the radar beam was narrow enough to resolve clearly many of the smaller features (note the lake at the right-hand edge of the island).

The echoes which go to make up a PPI picture are in themselves worthy of attention. Radar echoes arise through the r-f current induced in the target as the outgoing radar signal passes over it. But the reflection of signals is by no means limited to metallic targets. When the target is non-conducting a displacement current, similar to that in the dielectric of a capacitor, is induced and gives rise to a re-radiated wave. In general, the echo is produced by the discontinuity in the electrical properties between the target and its surroundings, and this discontinuity may be either in the electrical conductivity or the dielectric constant. In fact, a discontinuity in magnetic permeability is equally effective, but the magnetic property is usually overshadowed by the conductivity effect.

It is clear, then, how non-conducting sands can give rise to echoes. But it is not so clear why echoes from land should be stronger (as their relative brightness testifies) than the echoes from surrounding sea water, which is a better conductor. The answer is found in the fact that the surface of the sea is much smoother, electrically, than the surface of the land, and hence the land reflections are scattered backwards to the radar. The sea reflections are stronger, but in form they closely approximate the specular reflection from a mirror and hence glance off at an angle, away from the radar. The contrast displayed by terrain echoes depends primarily on such differences in the scattering properties of the reflecting surface, and only secondarily on the relative conductivity or dielectric constant of the material in it.

In line with this reasoning the PPI picture shown in Fig. 7 is of particular interest. This picture was widely misinterpreted in the daily press as a radar picture of a four-motored bomber. Actually it is the radar picture of the shadow of the bomber on the ground beneath. The direct echo from the aircraft itself shows up as a bright spot near the center of the wing span. The aircraft was so close to the radar that it intercepted a large part of the signal and thus cast a shadow of itself on the ground. Outside the shadow, echoes from the ground formed the outline shown. Such pictures are freaks, of course; this one was not understood for several days after it was first photographed.

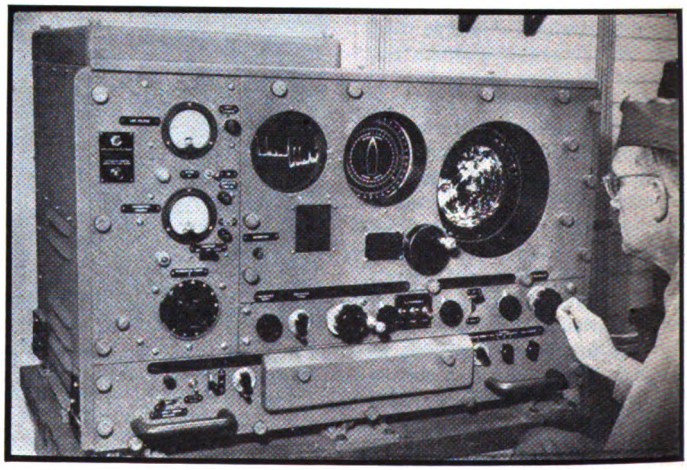

FIG. 10—The Navy's type SG radar, showing (left to right) A-scope, relative azimuth indicator, and PPI-scope. The A-scope resembles an ordinary test oscilloscope, indicating the relative timing of the transmitted pulse and the succeeding echoes. It is used for tuning to peak efficiency and to measure accurately the range of particular targets, selected from the PPI at the right

Not all PPI pictures are easy to interpret. An important application, radar bombing, requires extensive experience on the part of the operator. An example of the picture presented by a radar bombsight is shown in Fig. 8. The individual targets are discernible, but only when you know what to look for. The radar contrast is not great between a manufacturing plant as a target on the one hand and the nearby buildings and countryside on the other. To aid in identifying targets, reconnaisance runs were often made and the PPI pictures

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photographed for comparison with aerial photographs of the target area. The most effective use of the radar bombsight was in close partnership with the optical (Norden) bombsight. The bombardier operated the Norden sight in the conventional manner, setting in his corrections for drift, etc in accordance with readings given by the radar operator. Both continued to track on the target, and the final bomb release was controlled visually if a break in the clouds permitted. Otherwise the bombs were dropped on the basis of radar indications fed into the Norden computer.

Still another type of PPI picture is the radar relief map, an example of which is shown in Fig. 9. This is a shadow picture, the nearby sides of the terrain features (in this case a mountain range) showing brightly against the shadows on the far side.

The PPI picture is evidently an excellent device for navigation when sharp contrasts are available. Since such contrast is generally available along coastlines, the PPI is especially useful for the navigation of surface craft. One of the most widely used shipboard radars is shown in Fig. 10. Three indicators are shown. At the left is the type-A indicator, a c-r tube which displays the transmitted echo and the echo reflections along the direction occupied by the radiated beam at any instant during its rotation. Next is the relative azimuth indicator which shows the axis of the ship (note figure at center of dial) with respect to true north or some other reference direction. At the right is the PPI indicator which shows the plan view of all radar echoes within range, oriented against the axis of the ship.

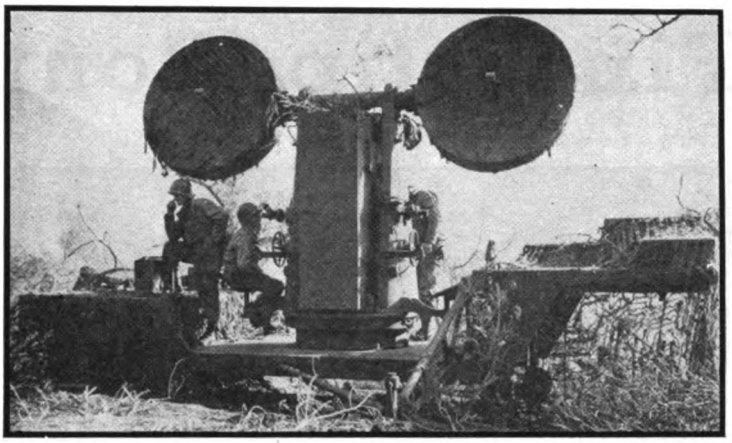

FIG. 12—Mickey Mouse, or SCR-547, a unit made to replace the visual range finder in AA gunfire. This 10-cm radar can measure the distance to aircraft at a distance of 20 miles and with an accuracy of 25 yards

Gunfire Control

To determine the position of an airplane or ship accurately enough to control gunfire is a problem which requires for solution more than the use of high frequencies and narrow beams. In addition, it is necessary to refine the accuracy of the angular indications by using lobe switching (see "The SCR-268 Radar," ELECTRONICS, September 1945) or its close relative, conical scanning. Pending release of details on this equipment, it may only be stated that such methods permit spotting the position of an aircraft accurately to a few hundredths of a degree in elevation and azimuth. Precise timing circuits determine the range to an accuracy of a few tens of yards in range.

Since gunfire at high speed targets must be computed to lead the target, the radar data is fed into a gun-control computer which controls the action of guns automatically. Figure 11 shows a 90-mm anti-aircraft battery controlled by the SCR-584 radar, one of the outstanding radar sets of the war. Another gunfire control radar on which technical details are available is the SCR-547, shown in Fig. 12. This device possesses separate antennas for transmitting and receiving and indicates only the range to the target. The frequency used is in the microwave region, roughly 2800 mc (wavelength 10.7 centimeters). The radar is put on the target optically and indicates the distance to the target within 25 yards, which is equivalent to timing the echo to an accuracy of 0.15 microsecond. Details of the circuits which accomplish this remarkable result will be published in an early issue.—D.G.F.

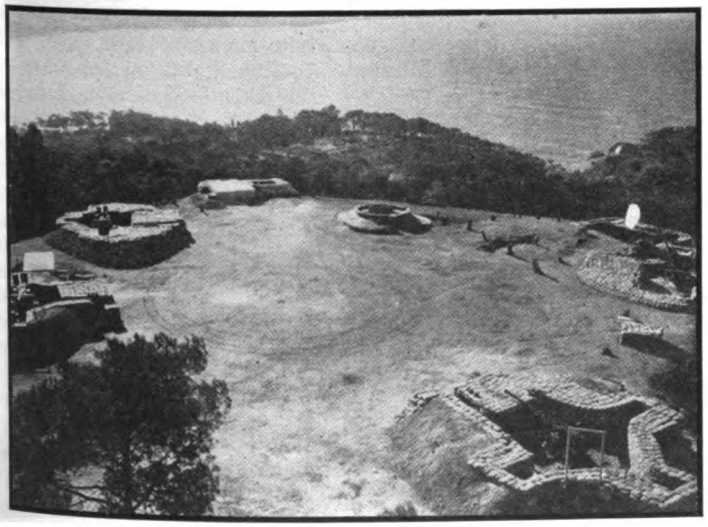

FIG. 11—A 90-mm AA battery protecting the invasion coast in Southern France. The fire-control radar, barely visible at the right (radiator painted out for security reasons), aims the guns automatically with the aid of a computer which introduces the necessary lead. This combination stopped the buzz-bomb attacks on England

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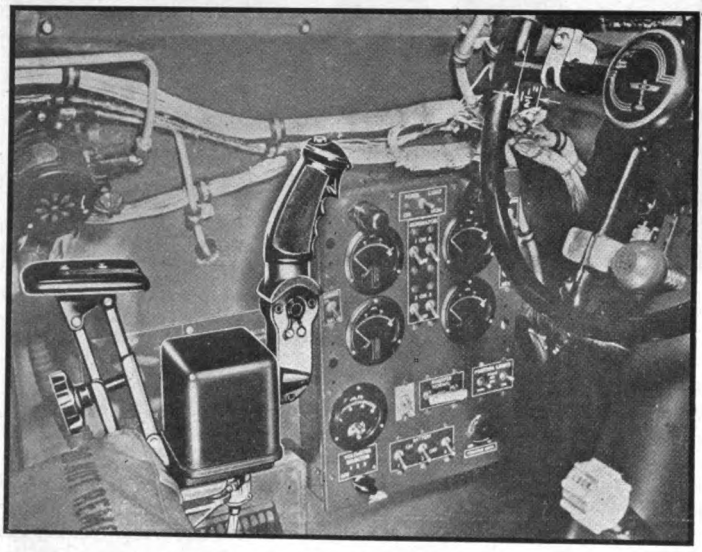
Fingertip Control FOR



Installation of formation stick in B-17G bomber. Autopilot release switch is clamped on a spoke of the control wheel, 1½ inches in from the rim, and is pressed in case of autopilot damage by enemy fire, to restore all manual controls

PILOT fatigue is one of the big problems of long-range bombing missions. Maneuvering a 70-ton airplane full of bombs and gasoline for long hours, holding a tight formation through flak and fighter opposition, and still being alert for every move of the flight leader through the bombing run and all the way home again . . . all this often left pilots with barely enough strength to crawl out of their seats at the end of a mission. The Minneapolis-Honeywell electronic automatic pilot was used for straight-and-level flight, but for maneuvers the human pilot had to operate the controls manually. Usually the combined efforts of both pilot and copilot were required to keep a plane in formation when rough weather made control difficult.

The answer to this problem has been found in the formation stick, an adjunct to the automatic pilot. It provides a means for rapidly maneuvering the largest bomber with very little pilot effort. Operated in a similar manner to the joy-stick on small aircraft, this control allows the pilot (or copilot) to bank, climb, or dive his plane by merely moving the formation stick away from its neutral center position. The degree of bank and turn and the rate of climb or glide are proportional to the displacement of the stick in its two axes of movement. Since it automatically provides coordinated turns, it transforms the airplane into a two-control ship which won't spin.

Pilot Tries Discarded Model

The first fingertip control was built in 1943. Since our planes were not yet flying wing-tip to wing-tip as they were later forced to by enemy fighter tactics and since other more pressing problems needed solving, the project was shelved until a strange trick of fate brought it into the light again. It happened this way. A young army pilot, visiting Minneapolis, picked up the discarded first model from a corner of the flight research hangar and secretly installed it on his B-17. He later flew the airplane into combat over Germany, where it attracted the attention of a senior officer. Army Air Force technicians pressed for immediate production. A short time later (in the fall of 1944) a redesigned stick came off the production lines. Since then it has been installed on Flying Fortresses, Liberators, and B-29 Super Fortresses.

Relation to Autopilot

The principle of the stick's operation is quite simple. As explained in Electronic Autopilot Circuits, p. 110, ELECTRONICS, Oct. 1944, the autopilot electrical bridge system is made up of three channels—one each for aileron, rudder, and elevator control. Without the formation stick each of these channels functions to maintain the airplane in a predetermined attitude by operating its corresponding control surface. The only way for the pilot to change course is by means of the turn control knob, which is not convenient for rapid course changes, and in addition does not allow control of the elevator surfaces.

The formation stick is essentially two potentiometers mounted at right angles to each other, with provision for the pickup wiper on each potentiometer to be driven by movement of the stick in a corresponding direction. These potentiometers introduce electrical signals into the autopilot bridge circuits calling for control surface movement. When the stick is moved backward or forward, a signal in the elevator channel causes the elevator to be driven so that the airplane will either climb or glide. **A side movement of the stick, on the other hand, produces a coordinated turn by introducing signals into both the aileron and rudder channels, plus a measured up-elevator response to hold the ship's nose up. Therefore, if the electrical system is properly adjusted beforehand, it would be impossible for the operator to accidentally make the plane slip or**

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FORMATION FLYING

Pistol-grip formation stick, newest accessory for C-1 electronic autopilot, permits effortless maneuvering of largest bombers during wing-tip to wing-tip flying in any weather, and provides servo boost for rapid changes in course or altitude during combat action

By D. G. TAYLOR and GORDON VOLKENANT

Chief Mechanical Engineer *Coordinator, New Products Research*
Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

skid when using the stick. Of course, climbing or gliding turns can be obtained with diagonal movements of the stick.

Function Selector Switch

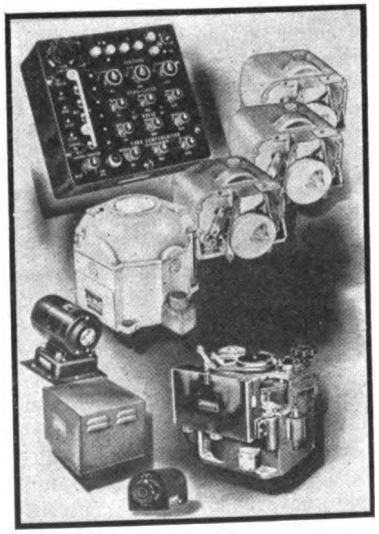
Two formation sticks (one each for pilot and copilot) are installed in the airplane. A special switch called the function selector has four positions which control the authority of the stick as follows: (1) ON SERVO BOOST (gyros off), (2) OFF (autopilot knobs now maneuver the plane), (3) ON (gyros continue to stabilize the plane), and (4) ON ELEV. ONLY. The switch assembly is made up of five cam-operated switches, with the cams mounted on a central shaft. These switches activate relays which are used to make the actual load circuit changes.

In the operational procedure, the autopilot master switch is first turned on, and a few minutes allowed for the gyros to warm up. The two basic sensing units for the autopilot, the vertical flight gyro providing stability in pitch and roll, and the directional stabilizer gyro performing the function its name implies, also serve the formation sticks.

The next step is to engage the servos, which mechanically drive the airplane's control surfaces in response to power signals from the autopilot amplifier. Assuming that all flight adjustments are correct, the airplane is then being flown by the autopilot. During this setting-up procedure the function selector has been at OFF, indicating that the formation sticks were inoperative.

Circuit for OFF Position

A schematic circuit for the autopilot with formation sticks is shown in Fig. 1. In the lower center the internal switches of the function selector are shown at OFF position. Note that the center switch grounds the aileron and rudder channels through the turn control, thus giving normal autopilot operation. The elevator channel is grounded through a resistor and the center tap on the formation stick elevator potentiometer. Since this potentiometer is not energized in this position of the selector, an accidental movement of the stick will not affect autopilot operation. (Because the current flow of any signal is extremely low, resistances of this order to ground have a negligible effect on the electrical characteristics of the autopilot without formation stick. The 600-ohm resistor is used to reduce elevator signals when the formation sticks are energized.)



Automatic units controlled by the formation stick in the C-1 electronic autopilot

Circuit for ON Position

When the function selector knob is moved to ON (position 3), the first switch energizes the stick potentiometers, the second makes the ECO and DAL delay switch circuits operative (see a following paragraph for explanation), and the third switch removes the direct ground of the turn control so that formation stick signals affect the aileron and rudder channels. The fourth and fifth switches have no effect in this position.

Effect of Stick Movements

With the formation stick circuit thus energized, note that the pilot's stick is the effective one. However, a transfer switch is located on top of each stick which, when pressed, transfers control away from the opposite stick. If the copilot's transfer switch is pressed, the transfer relay solenoid is grounded, pulling in the contacts necessary to give the copilot control and providing a hold-in ground to keep the solenoid energized. As can be seen in the diagram, the pilot's switch will return control to him even if the copilot's switch is depressed, since it effectively grounds the circuit ahead of the transfer solenoid.

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When the pilot's stick (or co-pilot's if control has been transferred) is moved sideways, a voltage signal from the banking potentiometer is introduced into the turn control bridge, unbalancing both the aileron and rudder channels. A voltage above ground is produced at the grid of the first tube of the amplifier in each of these channels, and servo movement is immediately started through the amplifier-controlled relays (not shown). Sufficient servo movement will be produced to rebalance the aileron and rudder bridges by movement of the balance potentiometers on the servos (shown as part of the autopilot bridges). Then, as the airplane responds, the vertical flight gyro will measure the angle of bank and put in its own rebalancing signal, causing the servo to drive the ailerons back to streamline position.

When the stick is allowed to return to neutral position, the opposite action takes place until the airplane is again leveled and all circuits balanced.

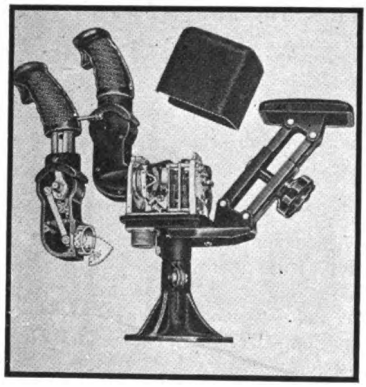
Action of Delay Switch

Whenever the stick is moved off center, a locking switch (shown near the lower center of the diagram) is closed, energizing the delay switch and heating a piece of resistance wire within it. As this wire is heated, it expands and allows the spring to close the grounding contact for the locking relay. (This action occurs in a fraction of a second, and serves no function until the stick is again centered). The locking relay energizes the directional arm lock (DAL) and erecting cut-out (ECO) circuits. The DAL locks the directional panel of the autopilot to prevent a corrective signal being introduced as the airplane moves off its established heading, while the ECO acts in the vertical flight gyro to prevent the gyro from erecting perpendicular to the floor of the airplane during the bank.

Elevator Action

After the stick is back in center position the delay switch described above momentarily maintains a ground for the locking relay until the airplane has had time to recover straight-and-level flight.

The preceding action takes place when the stick is moved to one side or the other. The only elevator action is a small amount of up-elevator provided by the up-elevator potentiometer of the vertical flight gyro to maintain the airplane's altitude during turns. However, if the stick is moved forward or backward, either without side movement or while a turn is being made, the down or up elevator called for will be provided by servo



Construction of formation stick

movement. The signal is produced by the elevator potentiometer of the formation stick and is sent up through the elevator input channel to the amplifier, where it causes the amplifier to produce servo action. Balancing and return to level flight take place in a manner similar to the action in the aileron channel. With elevator signals, however, there is no accompanying action of the locking relay.

Circuit for ON Servo Boost

Two additional positions are provided for special flight conditions. During tight formation flying, for example, it is often necessary for the pilot to make rapid changes in course or altitude in order to maintain his proper position in the formation. There might also be emergencies when banks greater than those allowed by the gyros would be necessary. When flying manually this would mean extreme and rapid movement of the controls. The formation stick performs this job when the selector switch is turned to ON SERVO BOOST (position 1). The stick then controls the individual servo units directly, without any stabilization or balancing out by the gyros, and under this condition the airplane must be flown as if it had no autopilot and the sticks were mechanically connected to the control cables.

Looking at the action of the function selector switches for this type of operation (bottom to top), the formation stick potentiometers are still energized. The ECO is not needed and therefore not energized since no gyro balancing is used, and the DAL circuit is controlled by a different switch in this type of operation. Aileron and rudder signals reach the autopilot channels only through a 500-ohm resistor which serves to reduce them slightly. Elevator signals reach the autopilot channel through a 600-ohm resistor (the same as in normal stick control) and the fifth switch performs its function of energizing the servo relay and also the DAL so that it is constantly locked during ON SERVO BOOST operation.

Direct control of the servos without one of the gyros balancing out the formation stick signals is obtained by operation of the servo relay, which shorts out a portion of the rudder bridge and transfers the aileron and elevator bridges to semi-fixed trimming potentiometers. Note that the only balancing of formation stick signals is performed by the servo potentiometers, and that the signals are then sent directly to the amplifier tubes through trimming or centering potentiometers on two of the channels, and simply shorted around the autopilot rudder potentiometer in the rudder channel. These adjusting potentiometers (plus a number of others) are semipermanent settings, and are located in the junction box serving all three channels.

Circuit for Elevator Only

Switch position 4, ELEVATOR ONLY, is for use in bombing. In a high-altitude bomb run it is essential that a constant altitude be held until the bombs are released. If altitude varies during the run, the mechanical calculations of the bombsight will be in error and the bombs will miss their target. With

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the standard autopilot in use it was necessary for the pilot to adjust a small knob or to electrically disconnect the elevator control and manually maintain altitude. In addition, stabilization of flight in the pitch axis of the airplane (up and down) was removed.

With the stick in use, ELEVATOR ONLY position allows control of this channel only, without interfering with the work of the bombardier who is constantly introducing corrections into the aileron and rudder channels by means of his bombsight. Also, every stick movement is automatically stabilized by the gyro of the autopilot so as to maintain accurate flight. Small deviations due to air conditions are corrected before the pilot may be aware of them.

In the ELEVATOR ONLY position the potentiometers are still energized, the DAL and ECO circuits are again dead, the turn control is grounded to eliminate any aileron or rudder signals from the formation stick, and the fifth switch is inoperative. The fourth switch is now active, grounding the elevator circuit through a 300-ohm resistor so that only a limited amount of elevator control is available. This gives a more cautious reaction to stick movement at a time when altitude must be carefully held.

General Considerations

As a safety precaution for the whole system, emergency disconnect switches are installed on each control wheel. In case of an autopilot malfunction, such as might occur if part of the system were destroyed by enemy fire, pushing either button will immediately disengage the entire autopilot including the formation sticks.

Several auxiliary functions are designed into the stick. To prevent abrupt and violent attitude changes and to give the pilot a control feel, a mechanical brake and centering mechanism are installed in each axis of movement. In addition, a trigger switch on each stick operates the microphone, replacing a switch used on the control wheel when the plane is being flown manually. The addition of an arm rest on the complete assembly makes it more convenient and less tiresome to use.

The use of formation sticks solves the control problem of designers who are planning huge postwar transports and passenger planes, since a one-pound pull on the stick takes the place of a hundred-pound pull that might be necessary on the control wheel. Enthusiastic reports on its wartime use received by Air Technical Service Command presage a successful peacetime future. When installed on postwar aircraft where automatic flight control is a necessity, this device will substantially contribute to the simplification of control problems.

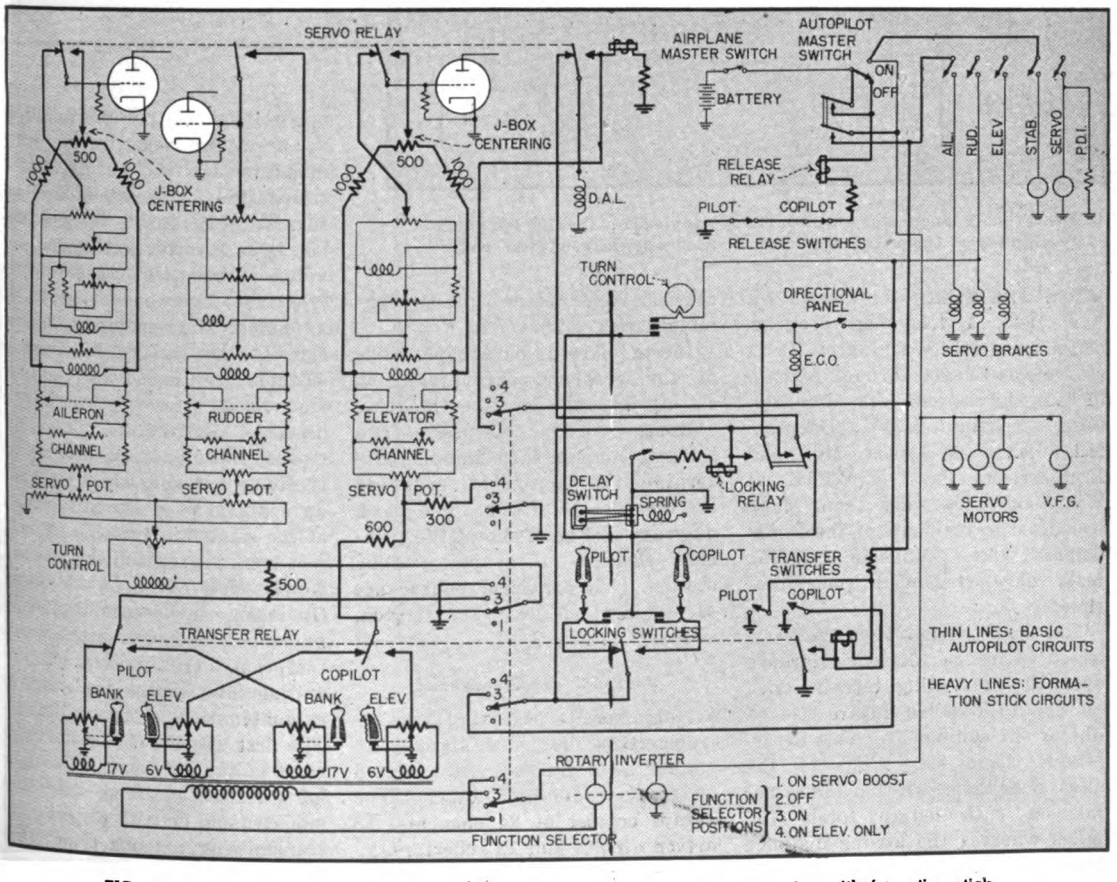

FIG. 1—Schematic circuit diagram of Minneapolis-Honeywell C-1 electronic autopilot with formation stick

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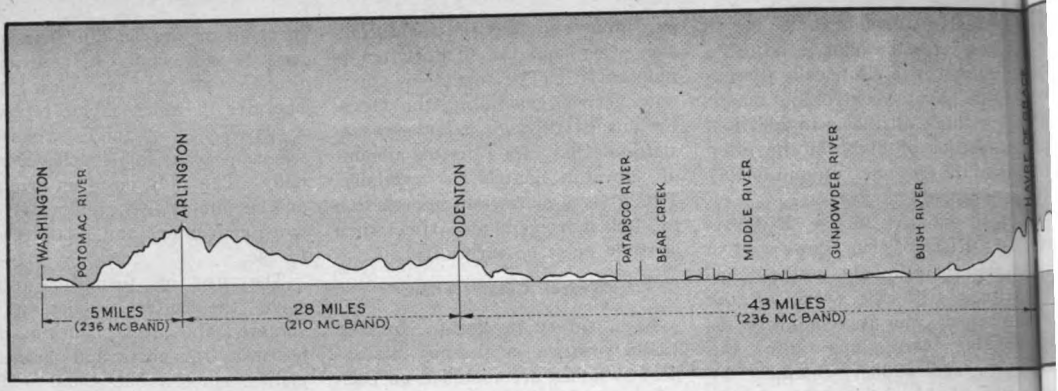

FIG. 1—Profile of the vhf multiple-relay television network route between Washington and Philadelphia, showing the relative heights of the two terminal stations and the four hilltop relay

VHF Multiple-Relay

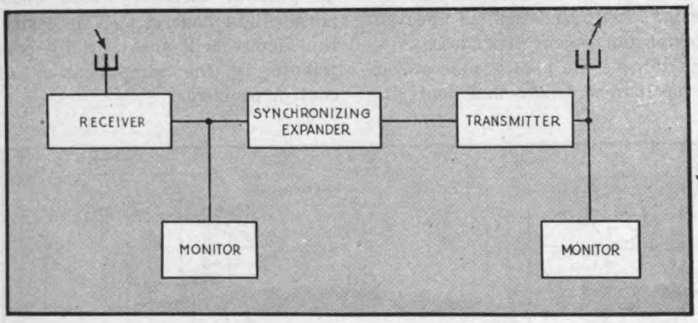

FIG. 2—Block diagram of a typical hilltop relay station, showing the principal elements of equipment, illustrated in detail elsewhere in these pages

By F. J. BINGLEY
Chief Television Engineer
Philco Radio and Television Corp.
Philadelphia, Pa.

ON THE EVENING of April 17, 1945, a television program originating in a Washington, D. C. studio was relayed through a chain of four vhf stations located on hilltops at Arlington, Va., Odenton, Md., Havre de Grace, Md., and Honeybrook, Pa., to WPTZ at Wyndmoor, Pa., and from there broadcast to residents of the Philadelphia area. Multiple relaying tests have continued since that time.

The four hilltop sites were selected to insure 100-foot clearance over all intervening terrain, with an eye to possible future use of uhf or shf equipment. This necessitated some staggering of the sites, with the result that the transmission path length totals 156 miles whereas the airline distance between Washington and Philadelphia is 143 miles. A profile of the network route between the two terminal cities is shown in Fig. 1.

In the following paragraphs some of the problems encountered in setting up and operating the relay stations will be discussed, and hitherto unpublished details concerning the equipment employed therein will be given. The block diagram of Fig. 2 shows the principal elements of a typical relay station. The physical appearance of one such station, at Arlington, is shown in Fig. 3.

Antennas and Frequencies

Antennas for receiving and retransmitting the video signals are similar in design, but are mounted on separate 100-foot towers. The arrays consist of 24 elements, 12 driven dipoles and 12 reflectors.

The driven elements, shown in Fig. 4, are half-wave dipoles. Two master elements in the center of the array are connected through a matching box to the receiver or transmitter by means of a ⅜-inch coaxial cable. Inside the matching box is an inverter section that provides a balanced transformation from the single-ended line to the antennas. The remaining 10 driven elements are end-fed, by means of suitable high-impedance transmission lines, from the two master dipoles.

One difficulty arose because the receiving antenna, which must pick up a signal of a few millivolts, is at the same site and only about 75 feet from the transmitting antenna, which sends out a 40-watt signal. Obviously, the transmitted signal might be expected to interfere with reception. This problem of intra-station interference was solved by a combination of two expedients. The first was the physical arrangement of the antennas. At each relay site, the receiving antenna is mounted end on with respect to the transmitting antenna tower. The transmitting tower is at a null point for the receiving antenna's

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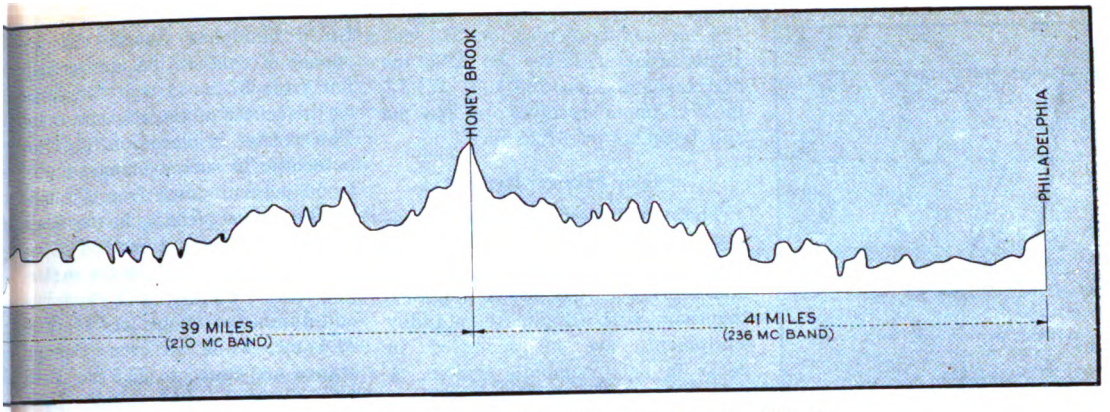

stations involved. Line-of-sight clearances of at least 100 feet were desired. This involved staggering of the relay stations but added only 13 miles to the transmission path

Television Network

Detailed description of a six-station chain through which video programs originating in Washington are telecast in the Philadelphia area. Staggered frequencies within the 210 and 236-mc bands are used, but uhf or shf equipment should ultimately prove feasible

pattern, which is shown in Fig. 5. Thus, the transmitting antenna itself may be placed in any position on its tower, since this tower is at the point of lowest sensitivity for the receiving antenna.

To further reduce local interference, the receiver and transmitter at each relay station operate in two separate frequency bands. This is possible because the transmitters in the network are operated on staggered frequencies. Washington, Odenton and Honeybrook, transmitters 1, 3 and 5, transmit in the 236-mc band (230-242 mc). Arlington and Havre de Grace, transmitters 2 and 4, transmit in the 210-mc band (204-216 mc). The result is that at the first relay point at Arlington, for example, the receiving antenna is picking up a 236-mc signal, while the transmitting antenna is sending out video intelligence on 210 mc.

A third device for reducing interference became necessary because it was found that the forward wave received at one relay station was obscured somewhat by the back wave from the next relay

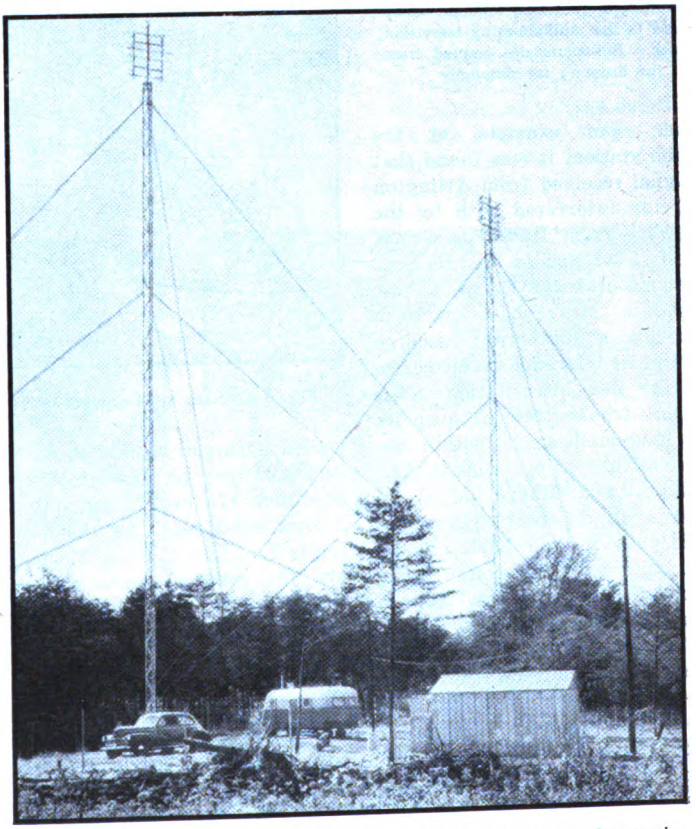

FIG. 3—Relay station at Arlington. The two 100-foot towers supporting receiving and transmitting antennas, the trailer in which equipment is housed, and the small metal building in which tools, spare parts and an emergency gasoline-engine driven generator are kept may be seen

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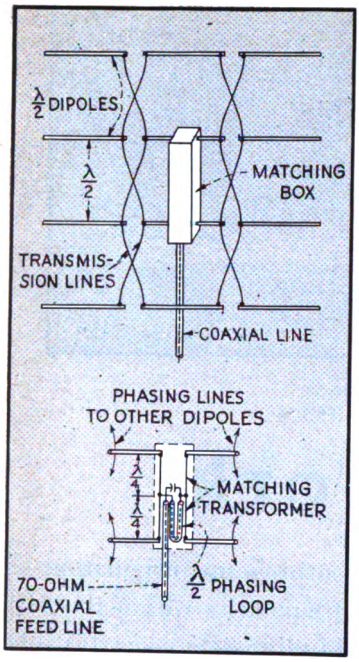

FIG. 4—Driven elements of a typical transmitting or receiving antenna array as used in the multiple-relay television network. Reflectors are omitted from the drawing for simplicity

station. For example, at the Odenton station, it was found that the signal received from Arlington was being interfered with by the back wave from Havre de Grace. The effect, viewed on the receiver picture monitor at Odenton, was similar to stray beat patterns caused by a diathermy machine near a home television receiver. To eliminate this inter-station interference, transmitter frequencies were staggered again within the two available 12-mc wide bands. Arlington and Havre de Grace transmit on different frequencies within the 210-mc band. These frequencies are far enough apart so that the beat pattern is of a frequency above the video acceptance band of the system. Similarly, Havre de Grace is protected against inter-station interference because Odenton and Honeybrook transmit at different frequencies within the 236-mc band.

Washington transmits on 236 mc. Arlington receives on 236 mc and transmits on 208 mc. Odenton receives on 208 mc and transmits on 234 mc. Havre de Grace receives on 234 mc and transmits on 212 mc. Honeybrook receives on 212 mc and transmits on 238 mc. WPTZ in Wyndmoor receives on 238 mc and telecasts on 67.25 mc.

Relay Receiver Design

The relay receiver, receiver monitor, synchronizing expander, relay transmitter, transmitter monitor, and the associated power supplies, together with duplicate standby equipment, are all mounted in racks in an automobile trailer. A typical trailer floor plan is shown in Fig. 6. Two views of equipment in a trailer are shown in Fig. 7 and Fig. 8.

In the relay receiver a grounded-grid cathode-driven r-f amplifier, R_1 in Fig. 9, is used to step up the received signal and feed it into a push-pull mixer, R_2, which also receives a signal from a line-controlled push-pull oscillator, R_3. The oscillator may be tuned to operate at either 171 or 275 mc. In the 210-mc band receivers the oscillator is tuned to 171 mc, 39 mc below the received signal's carrier frequency. In the 236-mc band receivers, the oscillator is tuned to 275 mc, or 39 mc above the received carrier. This staggering of oscillator frequencies is necessary in order to reduce interference from harmonic beats produced between the local transmitting carrier and the local receiver oscillator.

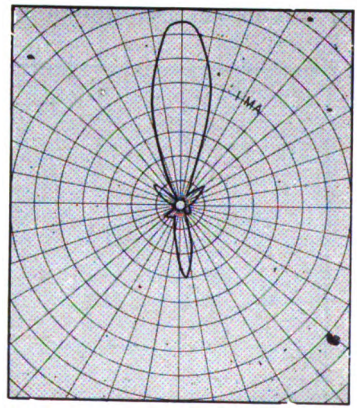

FIG. 5—Pattern of 24-element array

From the mixer, the i-f signal goes to the i-f amplifier section, tubes R_4 through R_{11}, consisting of eight frequency-staggered, single-tuned bandpass stages. The response of this section is essentially flat from 37 to 41 mc, with 39 mc as the center of the response curve. The carrier is placed on this characteristic in such a manner that it is 50 percent down from the peak of the characteristic, in the familiar single-sideband method of reception. The i-f stages are so staggered that the first and succeeding odd-numbered stages are tuned to 41.5 mc, while all even-numbered stages are tuned to 36.5 mc. Each i-f coil is damped suitably by a load resistor. Typical response curves are shown in the lower right-hand section of the circuit diagram.

After amplification, the 39-mc i-f signal goes to a conventional diode detector, R_{12}, and the resultant video signal is sent through a cathode follower, R_{13}, acting as a buffer stage, to the synchronizing expander.

The video signal is also fed to a 10-inch picture tube for monitoring received picture quality, and to a 5-inch oscilloscope used to check the wave form of the received signal. The choke in the plate lead from the detector to the cathode follower acts as an i-f filter.

A typical relay receiver, such as the one shown schematically in Fig. 9, is illustrated in Fig. 10.

Synchronizing Expander

The video signal from the receiver enters the sync expander with the white positive and the sync pulses down. Note the wave forms of Fig. 11. The purpose of the sync expander is to amplify the synchronizing voltage content of the composite signal more than the video voltage. This is necessary because of the non-linear amplitude characteristics of the relay transmitters in the synchronizing region; that is, the sync content of the video signal tends to be compressed in transmission, and the sync expander compensates by amplifying the sync.

In the sync expander, the video signal first passes through three amplifier stages. At the second stage, a degenerating variable resistor in the cathode circuit serves as a video gain control.

When the signal leaves the third amplifier, S_3, the sync pulses are up,

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as the waveform indicates. The circuit of d-c restorer S_5 acts to maintain the sync pulse tip level at a constant d-c potential in the plate circuit of amplifier S_4, regardless of changes in picture content. In the plate circuit of S_4, the sync pulses are amplified and inverted. Here is where the sync expansion takes place. Note that the plate load of S_4 consists of two parts: (1) a fixed resistive load, R_1, connected to a 380-volt regulated supply, and (2) a variable resistive load, separately connected to a 230-volt regulated supply. The variable load, S_6, comprises a diode circuit such that its resistance, which is in parallel with the fixed load, is practically infinite during the synchronizing pulse, when the diode is not conducting. However, this resistance becomes finite when the video level is reached, since at that time the diode will conduct current. Thus the total plate load, and hence the amplification, is greater during the sync pulse. Correspondingly, the two resistive loads in parallel produce a lower total plate load, and thus lower voltage amplification from S_4, for the video intelligence.

Next comes a cathode follower circuit, with S_7 and S_8 in parallel.

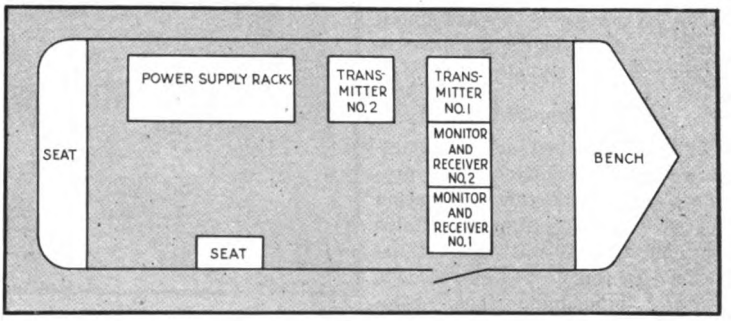

FIG. 6—Layout in a relay station trailer. Power is obtained from 110-volt supply lines, except in cases of emergency, when externally housed gasoline-engine driven generators are pressed into service. Note that standby transmitters and receivers are provided

Small resistors are placed in the control grid leads to act as suppressors of parasitic oscillation. A larger resistance is added in the cathode circuit ahead of the output to the 70-ohm line. This degenerating cathode resistor acts to improve the linearity of the cathode follower. It also cuts down the gain of the stage from about 60 percent to 20 percent. However, as the video voltage applied at the grids of S_7 and S_8 is about 20 volts, a signal of 4 volts remains and is carried to the relay transmitter by the 70-ohm line.

Tube S_6, in the grid circuit of the cathode follower stage, merely acts as a d-c restorer. A potentiometer is used to set its bias at such a point that the sync pulse tip level is at the desired voltage regardless of changes in picture content.

The effect of sync expander action may be seen in Fig. 12. This graph shows output voltages at the plate of S_4 as ordinates and input voltages at the control grid of S_4 as abscissae. The knee of the curve appears at the point where the variable load assumes a finite value and, in parallel with the fixed results in a reduced plate load for S_4 and hence a lower voltage amplification. As the wavefom shows, this knee appears at the base of the sync

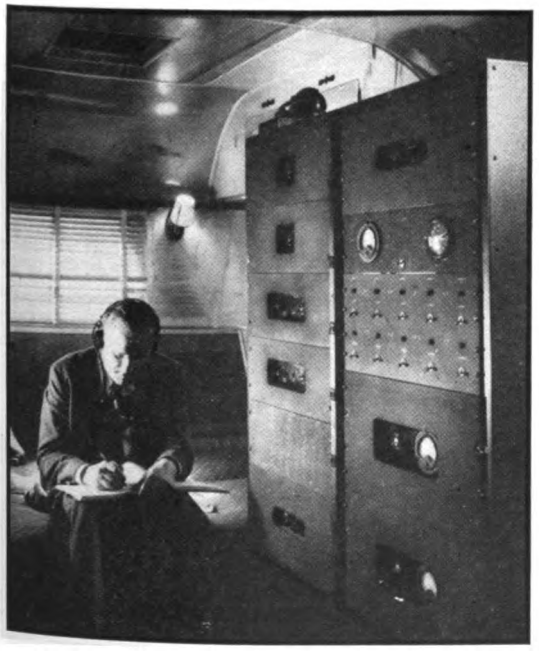

FIG. 7—Interior of a trailer, showing the operator talking to men at other points of the network via farmer's phone line

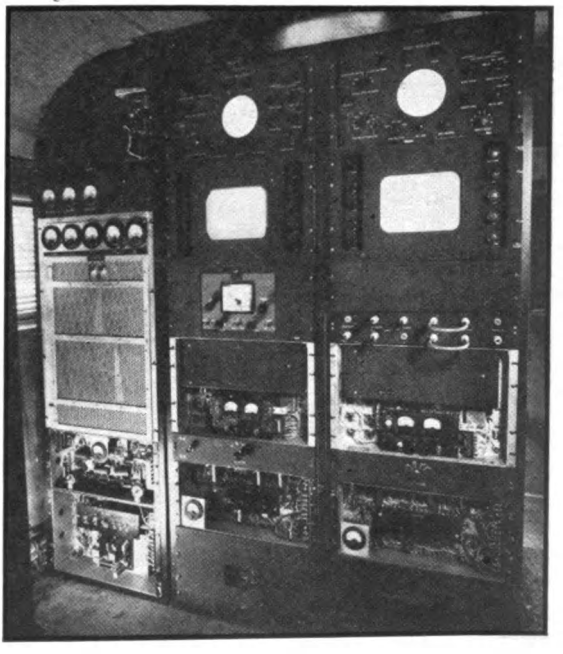

FIG. 8—Another view inside a trailer, showing one of the transmitters and the two rack-mounted monitor units

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pulses, so that the latter are amplified to a greater degree than the remainder of the signal.

Relay Transmitter

At each relay station in the network two transmitters are provided, one for regular operation and the other as a standby. Philco originally used 10-watt relay transmitters for remote pickup telecasts in the Philadelphia area. Similar transmitters were originally planned for each of the four relay stations in the Washington-to-Philadelphia network. Soon, however, it was found that this power did not give adequate signal strength for satisfactory definition and clarity of the received pictre. The signal-to-noise ratio was too low. Hence the transmitters were redesigned to include a power amplifier having an output of 40 watts. The problem af adding this power stage was simplified by "packaging" the power amplifier and connecting it to the 10-watt transmitter unit through a matching device. A close-up of the r-f portion of a typical transmitter is shown in Fig. 13.

Starting at the lower left corner of the transmitter circuit diagram shown in Fig. 14, note that the video signal from the synchronizing expander enters a modulator unit. The first stage of amplification

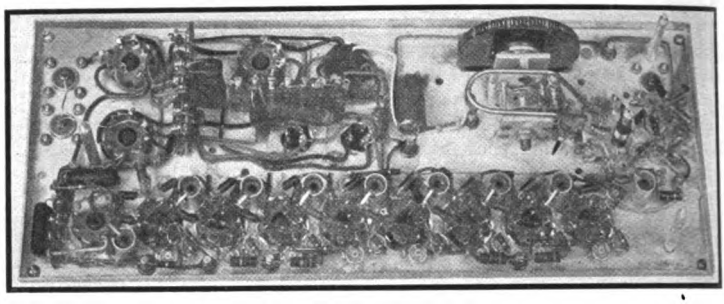

FIG. 10—Physical layout of a typical video receiver

finds the video (white up) applied both on the grid and cathode of T_1. The signal on the grid is varied by means of a 500-ohm potentiometer. The output is then amplified by the two stages T_2 and T_3, and we again have a positive video signal (white up) appearing on the grid of T_4. Diode T_5 acts as a d-c restorer to maintain the sync tip voltage level on the grid of T_4 at the voltage set by the 30,000-ohm rheostat connected to the plate of T_5. From the plate of T_4, the amplified video signal goes into the grid of the modulated stage of the transmitter through T_6, a voltage regulator. An r-f choke in this lead serves as a series video peaking coil. Capacitors are used to pass the high-frequency components of the video signal. Tube T_6 acts as a 150-volt battery and maintains the d-c component in r-f output.

The amplified video signal from the modulator is imposed on the r-f carrier, which is generated by a line-controlled oscillator T_7 and T_8 coupled to the modulated amplifier T_{10} through buffer stage T_9. Oscillator tuning range covers the two channels used in relaying, namely 204-216 mc and 230-242 mc.

In the original 10-watt transmitter design the output of the modulated amplifier T_{10} was coupled to the antenna by means of a coaxial line. When the 40-watt amplifier was added it was considered simplest from the standpoint of existing gear modifications to utilize half-wave inverter sections of coaxial line in the modulated amplifier, section and in the power amplifier section to couple these two stages.

It will be noted that a lead from the r-f output of the modulated

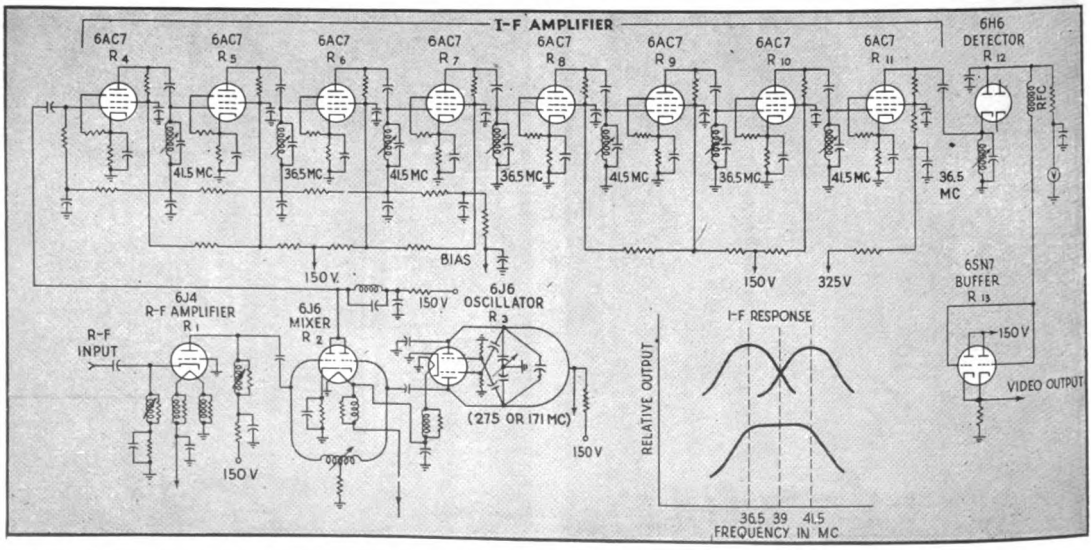

FIG. 9—One of the multiple-relay television network's video receivers, tunable to either of the two bands utilized by the system

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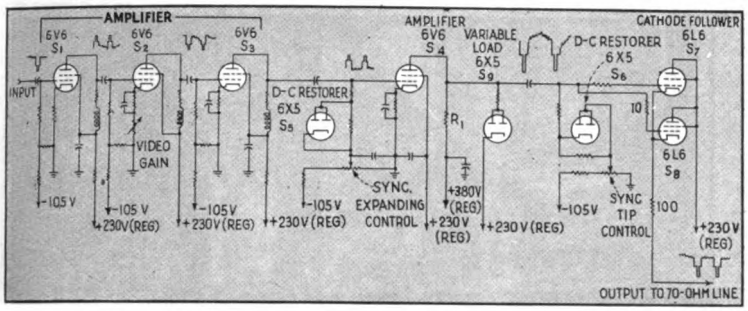

FIG. 11—Simplified schematic of the sync expander unit

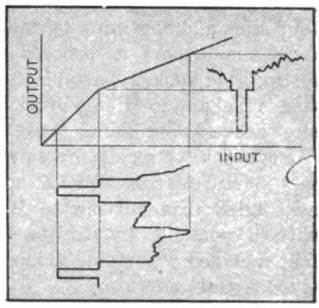

FIG. 12—Sync expander load characteristic

amplifier goes to the cathode of diode T_{11}. In the plate circuit of this diode is a load resistor which feeds a video signal to cathode follower T_{12}. This arrangement distributes the signal to a picture monitor and an oscilloscape through the test points shown.

The 40-watt power amplifier tubes T_{13} and T_{14} are operated as a grounded-grid cathode-driven stage. Because of the low plate-to-cathode capacitance when operated in this circuit, no neutralization is necessary.

A half-wave section of coaxial line is used in a manner similar to that employed for coupling between modulated amplifier and power amplifier to couple the latter to a coaxial line feeding the antenna.

Trailers and Other Equipment

Early in the design of the network, it was decided to mount all receiving, monitoring and transmitting equipment for each relay station, including a complete standby system and power supplies, in a suitable automobile trailer.

It was possible to obtain electrical power from the local lines near each of the four relay points. This meant that we needed to install, in addition to the antenna towers and trailer at each hilltop relay site, only a simple galvanized steel building to house spare parts, tools and an auxiliary gasoline-driven generator for standby power.

In the building a monoscope video signal generator has also been installed. It is pictured in Fig. 15. Arlington is the only relay station so equipped. Usually, the generator is used to televise a test chart and transmit the chart image along the network to simplify operational checks at all relay points and at the home station.

We use farmer's telephone lines to connect the television studios in Washington and Philadelphia with the four relay stations. In addition to these six phone installations, we have a seventh at the laboratories in North Philadelphia. Each point has a specified number of rings, and we can hold a seven-man round-table conversation when checking operation along the route.

Location of Sites

A study of 100-odd profiles of possible paths enabled us to select tentatively four hilltop sites for relay stations. After choosing the

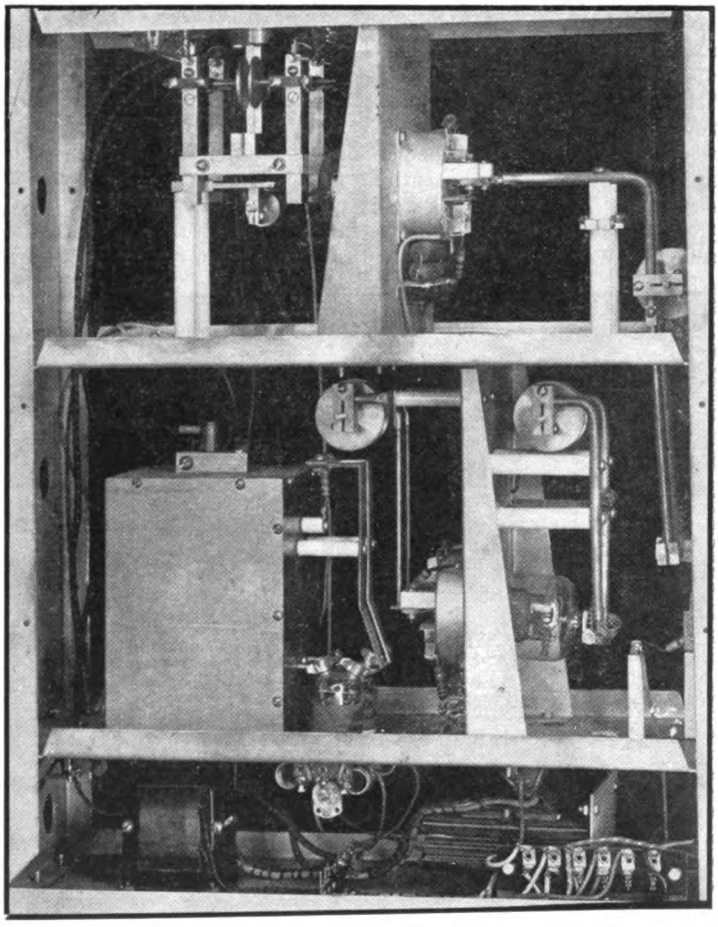

FIG. 13—Close-up of the r-f portion of a typical television relay station video transmitter

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four sites and obtaining permission from the owners to proceed with testing, we took a portable television receiver to Honeybrook, the site nearest our home base. At Honeybrook we received a satisfactory picture from WPTZ so we next tried transmitting to WPTZ with a portable transmitter unit that included a portable monoscope video signal generator.

By the time that this two-way test had been completed satisfactorily, our first trailer installation was available. We pulled it to Havre de Grace, the second site to be checked. Here we went through a one-way test, sending out a television picture from the portable monoscope in Havre de Grace to Honeybrook and then relaying it to WPTZ. At Odenton, procedure was the same except that the check included three relay points, Odenton, Havre de Grace and Honeybrook, as well as WPTZ.

At the fourth and last relay site, at Arlington, the permanent monoscope installation was used instead of the portable video signal generator. The same sequence was followed, however, in checking the picture transmitted along the entire network.

The final step was to establish a studio in Washington. The site

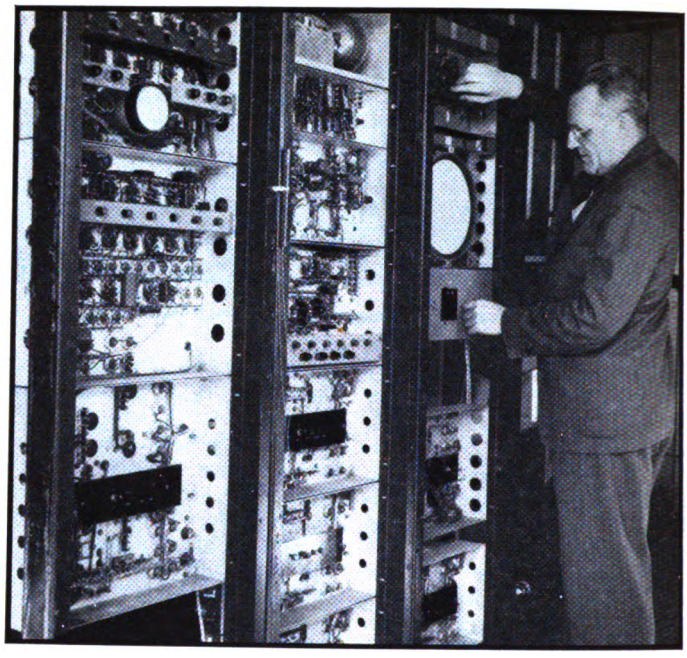

FIG. 15—Television engineer operating monoscope video signal generator in the steel shed at Arlington

eventually chosen was a corner suite on the top (14th) floor of the Hotel Statler. Cameras, lights, transmitters, monitoring and receiving equipment, and test apparatus are installed in this three-room suite. A large room on the corner is the actual studio, and two smaller flanking rooms are used for transmitting and control (monitoring) respectively. The antenna is a simple 3-element dipole on the roof, since the hop from Washington to Arlington is only about 5 miles.

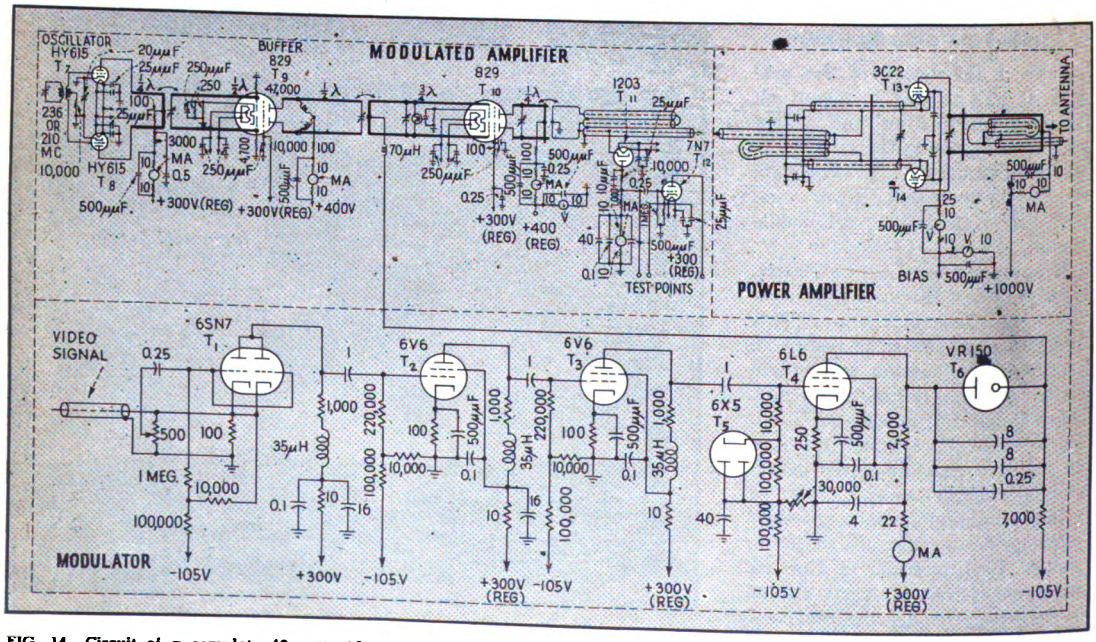

FIG. 14—Circuit of a complete 40-watt video transmitter. Originally 10 watts was fed to an antenna from the output of the modulated amplifier stage. The power amplifier was added later

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The Technical Basis of ATOMIC EXPLOSIVES

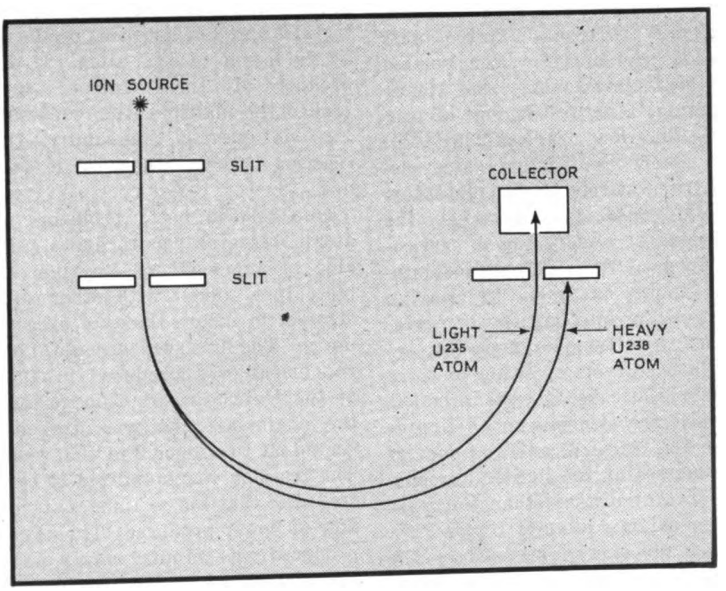
Based on information recently released by the War Department, this article describes the production and use of the two principal atomic explosives, uranium-235 and the new element plutonium

SEVERAL DAYS after the first atomic bomb attacks on Japan, to the surprise and gratification of the technical press, the War Department issued a 175-page report on the technical background of the atomic bomb project. The report was written by Prof. H. D. Smyth, head of the Physics Department of Princeton University and consultant to the U. S. Corps of Engineers, to supply as much information as national security would permit.

The document is a masterpiece of technical exposition and is recommended to every reader of ELECTRONICS who can secure a copy. Unfortunately, the report received but scant attention in the daily press and its distribution is not widespread. To rectify this situation, the editors have prepared from the report the following summary of the production and use of the atomic explosives.

Fission—The Fundamental Action

As is now well known, the production of atomic energy is accounted for by the energy-mass equivalence theorem first stated by Einstein in 1905. The equation states that a mass of m grams may be viewed as being equivalent to an energy of mc^2 ergs, where c is the velocity of light. This theoretical postulate was later proved through the study of radioactive materials. It was found that when a heavy radioactive substance undergoes a spontaneous transmutation, it breaks up into one or more elements of less total mass. The difference in mass appears in the form of radiant or kinetic energy, as evidenced by the radiations and particle emissions which accompany the transmutation.



An electronic method of separating desired U^{235} atoms from the U^{238} atoms which constitute the bulk of uranium metal. Here, utilizing a principle similar to that employed in a mass spectrograph, light U^{235} atoms are caused to move along a curved path to a collector, while heavier U^{238} atoms move along a path having a different radius and are blocked

The striking aspect of this process is the size of the quantity c^2 which relates the energy produced to the loss of mass. This quantity is 9×10^{20} ergs per gram. Thus 2.2 pounds of a substance (1 kilogram) completely transmuted into energy is equivalent to 25 billion kilowatt hours of energy, which is equal to the electrical energy generated by all the U.S.A. utilities over a period of two months. It is evident that if even a small portion of a gram of matter could be so transformed, an explosion of epic proportions might

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be made to occur. But the transmutations occuring in natural radioactive substances involve so small a percentage of the material present, and the mass change itself is so small, that no substantial concentration of energy occurs.

The search for practical amounts of atomic power was directed along two avenues: to find natural or artificial radioactive substances whose transmutations involved a large change in the atomic mass, and to develop means of concentrating these substances so that a large portion of the material present would undergo transmutation at once. Both of these avenues have been explored with almost superhuman intensity over the past five years, with the result which the world now recognizes as perhaps the greatest achievement of organized science.

Uranium and Plutonium

Two radioactive substances having the necessary large mass change have thus far been isolated on the scale necessary for atomic bombing: a natural isotope of uranium, known as uranium-235 (U^{235}), and a new artificially-created element, tentatively named plutonium (Pu^{239}). These substances have the property of undergoing a particular form of radioactive transmutation known as *fission* (a cleaving or breaking into parts) when irradiated with low-speed neutrons.

When an atom of either of these elements breaks up, the products formed are elements much lighter than the original, and the sum of the masses of the lighter elements is substantially less than the mass of the original atom of U^{235} or Pu^{239}. Hence the energy released by the fission is very great. Moreover, and most important, the fission is accompanied by the production of additional neutrons. Thus if but one neutron is originally present and only one atom is transmuted at the start, additional neutrons are produced which irradiate the nearby atoms, producing new fissions. The process builds up cumulatively and the disintegration of the whole mass of material is self-sustaining. This is the so-called chain reaction which is essential to the action of the atomic explosive.

For the chain reaction to proceed it is necessary that the number of neutrons produced in a given time exceed the number absorbed or lost by the system in the same time. This condition is expressed by an equation which is basic to the whole science of atomic power. A chain reaction occurs if

$$N\varepsilon pf\eta \geqq N \qquad (1)$$

where N is the number of free neutrons originally present and the factors $\varepsilon pf\eta$ represent the regeneration and loss of neutrons in the course of the atomic disintegration. Specifically ε is a factor greater than 1 representing the production of fast (high velocity) neutrons, p a factor less than one representing the loss of neutrons by resonance capture without succeeding disruption of the atoms, f is a probability factor representing the chance that the low speed (thermal) neutrons will be absorbed in the uranium or plutonium atoms and thus produce fission, and η is the number, between 1 and 3 of neutrons produced by the fission of each atom. If the product of these factors $\varepsilon pf\eta$ (called the multiplication constant, $k\infty$) is greater than unity, the reaction occurs; otherwise it does not.

One of the basic problems of atomic research was to find a suitable arrangement of uranium or plutonium, mixed with other substances, to insure that $k\infty$ exceeds unity. The first such successful arrangement was produced in 1942 at the University of Chicago, and the chain reaction was first observed on December 2 of that year. The reaction was stabilized or controlled so that $k\infty = 1$ and a steady flow of power produced. The power produced was minute, only ½ watt. But the principle was established, proving not only the feasibility of the atomic bomb itself, but indicating the process whereby plutonium could be manufactured on a continuous basis from uranium metal. This process was embodied in the Hanford, Washington, plant which began operation in September 1944 and has since served as one of the principal sources of atomic explosives.

Basic Requirements of an Atomic Bomb

There are several requirements which must be met in the design of an atomic bomb. First, the bomb must be stable and safe to handle prior to its release from the bombing aircraft. Second, it must be efficient in the use of the atomic explosive, which is a very precious material. The first requirement is satisfied by making use of the fortunate fact that the atomic explosive does not explode so long as the amount of material initially present is smaller than a certain critical size. By bringing several such small pieces together quickly, so that the sum of their masses exceeds the critical size, the explosion can be made to occur at any desired time.

The second requirement, efficiency, is met by confining the explosion in a strong and massive container or tamper, so that the disintegration of the desired amount of explosive occurs before the bomb flies apart. If no such container were provided the initial force would separate the explosive material into small pieces which, by themselves, would not disintegrate further. Even with such a container, the time available for completion of the chain reaction in the bomb is very short, of the order of milliseconds, so means must be taken for insuring complete migration of the neutrons through all parts of the explosive before the container releases its contents. This implies the use of fast neutrons as the detonating agent.

The reason that pieces of atomic explosive smaller than a certain critical size will not explode is readily seen from the following: In a small piece of material, the surface area of the piece is large compared with its volume, and the number of neutrons lost through the surface is so great, relative to the number produced, that sufficient multiplication of the neutrons to cause a chain reaction does not occur and the material remains stable. As the size is increased, however the volume increases faster than the surface area and the ratio of neutrons produced to these lost through the surface increases proportionately. The critical size is reached when the number of neutrons lost through the surface, and through the other losses indicated in Eq. (1), just equals those produced. In pieces larger than this,

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the chain reaction becomes self-sustaining and the explosion occurs.

For reasons of security the exact value of the critical size is not given in the report, but it is stated to be between the limits of 2 kilograms and 100 kilograms (between 4.4 and 220 pounds). The press has stated that a piece weighing 25 pounds is sufficient for the atomic bomb, but there is no official confirmation of this figure.

No other details regarding the bomb itself are available except the method of bringing the pieces of explosive together. The reaction will start when the pieces are brought in close proximity and the speed of the reaction is so great that the pieces might be blasted apart before they reach firm contact, with consequent lowering of efficiency. To avoid this, the pieces must be brought together in a few microseconds, and this is accomplished by shooting, with a gun mechanism, one piece at another with such force and at such high velocity that they merge into a solid mass before the explosion takes place.

Even though these precautions have been taken the full force of the atomic explosion has not yet been realized. Although the present efficiency is not reported, a report on the subject written in 1941 indicated that from 1 to 5 percent of the potential fission energy might be released before the material becomes so far separated as to cause the reaction to cease. On the basis of these figures it was stated that 1 kilogram of U^{235} would equal the effect of 300 tons of TNT. Figures released to the press regarding the first bomb dropped on Japan indicated an explosive effect equal to that of 20,000 tons of TNT, which would indicate a weight of U^{235} of about 67 kilograms (150 pounds), based on the above figures. If the efficiency realized is higher than that predicted in 1941 (as it may well be), the weight required to produce this effect is proportionately less. The weight is evidently not a deterrent from the standpoint of carrying the bomb in an aircraft, even considering the auxiliary detonating and containing structures. Nor is the size excessive, since 25 pounds of uranium occupy a cube only 3.3 inches on a side. But obtaining such amounts of the uranium or plutonium from natural sources, was a staggering problem.

Equations Behind the Atomic Bomb

Mass-energy equivalence theorem

$$E = 9 \times 10^{20} m$$

where E = energy in ergs
m = grams of matter

Chemical reaction producing plutonium

$$_{92}U^{238} + {}_{0}n^{1} \rightarrow {}_{92}U^{239} \rightarrow {}_{93}Np^{239} + {}_{-1}e^{0}$$
$$_{93}Np^{239} \rightarrow {}_{94}Pu^{239} + {}_{-1}e^{0}$$

where U = uranium
n = neutron
Np = neptunium
e = electron
Pu = plutonium

Subscripts indicate atomic number, or positive charges on nucleus
Superscripts give mass number, that is: the number of massive particles in the nucleus

Fission reaction (atomic explosion)

$_{92}U^{235} + {}_{0}n^{1} \rightarrow$ fission products + 200,000,000 electron volts (similar reaction occurs with plutonium, $_{94}Pu^{239}$)

Availability of Materials

Estimates place the percentage of natural uranium in the earth's crust at about 4 parts per million. Substantial deposits are known to exist in Colorado, northern Canada, Czechoslavakia, and in the Belgian Congo. By the end of 1941 only a few grams of purified metal had been produced. But by June 1942 deliveries of the brown dioxide of uranium, the basic raw material, had reached 30 tons per month. By Nov. 1942, 6000 pounds of pure uranium metal had been accumulated, and by 1943 upwards of 500 pounds of the metal were being produced each day. The cost at that time was 22 dollars per pound. Thereafter, improved processes were introduced and no further metal shortages have since occurred.

Uranium metal consists of two isotopes, one of atomic mass 238 (U^{238}) and the other of atomic mass 235 (U^{235}). The active portion, U^{235}, is present only to the exent of 1 part in 140 (0.7 percent). The remaining 99.3 percent of U^{238} so dilutes the U^{235} that in the natural state uranium does not react chainwise except when assembled in masses so great as to be completely impractical for purposes of bombing. The alternative was to remove the U^{238} from the U^{235} to permit its use in concentrated form. The compactness thus achieved permits easy transportation by aircraft and also permits achieving high efficiency in the bomb.

Separation of the U^{235} from U^{238} is far from simple. The two isotopes have similar chemical properties and hence cannot be separated by chemical processes. The only basis on which they can be separated is a slight difference in mass, amounting to about 1.3 percent. Thus the separation must be based on some physical process, involving a difference in the speed of the atoms as they move under thermal, mechanical or electric forces. Unfortunately, the difference in speed depends only on the square root of the mass ratio, and in a large group of atoms the speeds have statistical distributions which overlap. Hence the separation is only partial and must be repeated many times to produce even partially pure U^{235}. Of over a dozen methods of isotope separation known, four were considered capable of large scale operation in 1942, provided that truly heroic measures were taken in setting up the separation equipment on a large scale.

Since this approach would take time, and since there was great

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fear that the Germans might be well ahead in the same problem, another approach was sought, found and pursued independently. This second approach was the production and separation from uranium metal of a new element, plutonium.

During the study of the effect of neutrons on uranium, it was found that two new elements might be produced artificially. These two new elements have different chemical properties and hence are separable from the parent uranium by chemical means of much higher efficiency than the physical methods necessary to separate U^{235}. The production of plutonium starts when a neutron of proper speed enters the nucleus of U^{238} (the more plentiful part of uranium metal) and is absorbed there, giving rise to a new isotope of uranium, U^{239}. This isotope transmutes spontaneously, one half the atoms present changing in 23 minutes, into an intermediate element, neptunium, accompanied by the emission of a high speed electron. The neptunium thereupon transmutes (half-life 2.3 days) into plutonium, again with the emission of a high speed electron.

The plutonium has a half-life of over 1000 years, that is, it decays so slowly that in effect it can be considered a stable element. When its properties were first investigated, theoretical predictions were made that plutonium, like U^{235}, would undergo fission when bombarded with slow neutrons. This was later proved to be in case. Thus for all practical purposes, pure U^{235} and plutonium are equivalent as atomic explosives, whereas plutonium is considerably easier to produce and extract because large scale chemical processes may be employed. Moreover, the raw material from which plutonium is extracted is U^{238}, which constitutes 99.3 percent of natural uranium, and hence the plutonium obtainable from a given store of metal is potentially much greater than the amount of U^{235} (0.7 percent) present.

All these factors made plutonium production very attractive and plans to produce it on a large scale were drawn up. The scale of this effort can be estimated from the fact that at one time some 60,000 people were at work on the site of the Hanford, Washington, plutonium plant, and the total area under government control is nearly 1000 square miles. The temperature of the Columbia River has been raised an appreciable number of degrees by the cooling water discharged from the plant, which consists of three huge producing units and associated chemical separation plants.

Methods Used to Separate U-235

To insure a source of separated U^{235}, three plants were also set up in the Clinton Engineering District in Tennessee, each plant designed for a different method of isotope separation. The three methods used are gaseous diffusion, thermal diffusion, and electromagnetic separation utilizing the principle of the mass spectrograph. The thermal diffusion process was not used to produce the end-product, but rather to provide an enriched form of U^{235} to feed into the electromagnetic process.

The gaseous diffusion plant was planned in the winter of 1942-43 and a few sections went into operation in 1944. The completed plant was in full operation before the summer of 1945. Separation by gaseous diffusion is based on the fact that the light molecules of a gas mixture diffuse more readily through a thin sheet of metal than do the heavy molecules. For diffusion to take place, the sheet (known as a barrier) must have billions of tiny holes in it, none of which is larger in diameter than 0.0000004 inch.

One form of barrier, since improved upon greatly, is a thin sheet of silver-zinc alloy etched with hydrochloric acid. A gas containing uranium (uranium hexafluoride was used in the early work and other gases have been investigated) is placed on one side of such a barrier, at atmospheric pressure, and the space on the other side is evacuated. As the gas diffuses, the lighter molecules made up of the U^{235} isotope pass through the holes somewhat more readily so the mixture of gas which accumulates on the evacuated side contains a higher percentage of U^{235} than that on the other side. The enrichment in one such stage of diffusion is very slight, amounting to about 0.3 percent for UF_6, and not all this is realized due to reverse diffusion. To secure substantially pure hexafluoride of U^{235} the process must be repeated over and over again, roughly 4000 separate stages of diffusion being required to achieve 99 percent purity. The U^{235} metal can then be recovered from the gas by conventional chemical processes.

To secure large amounts of U^{235} by this process literally acres of barrier sheets, and thousands of pumps to evacuate the low-pressure side of each stage, were required. The steam power plant built to supply the power for this purpose is one of the largest ever built.

Thermal diffusion, the second method of separation, accomplishes separation of molecules of different weight by the effects of a temperature gradient. The method had been applied to gases prior to 1920 and had been used successfully to separate isotopes in Germany in 1938. The process adopted at Clinton makes use of the liquid, rather than gaseous, phase of uranium hexafluoride. The plant structure is much simpler than that required for gaseous diffusion and construction was completed in the summer of 1944.

The electromagnetic separating plant, the first large-scale producer of purified U^{235}, began operation in 1943 in a small number of units which were subsequently enlarged. The plant began large-scale operation at the end of 1944 and produced U^{235} of sufficient purity for use in atomic bombs. The principle of operation is basically that of the mass spectrograph, in which positive ions of uranium are accelerated electrically to a very high speed and then passed through a transverse magnetic field which causes the ions to move in circular paths, the radii of which are proportional to the atomic mass.

A diagram in these pages shows the basic action of such a separator. The lighter ions, containing the U^{235}, move through an arc of shorter radius, at the end of which is a slit through which the atoms pass to the collector. The heavy atoms of U^{238}, moving along another

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arc, are intercepted. This electronic method of purifying U^{235} is attractive in its simplicity, but prior to 1941 it was not considered suitable for large scale operations. The limitations were the difficulty of producng a large quantity of gaseous uranium ions, the wastage incident to forming the ion beam, and space charge effects in a dense beam of ions, all of which limited the yield of purified U^{235}.

The final form of mass separator, called a calutron (after California University, where it was developed), overcomes these limitations in several respects. The space charge is neutralized by ionization of the residual gas in the chamber through which the ion beam passes. A more copious source of ions was obtained by widening the slit of the ion gun, and controlling the divergence of the beam through space-variations in the applied magnetic field. In this way the current in the ionic beam, and hence the rate of collecting separated U^{235}, were vastly increased. The process was applied experimentally on a large scale by the use of a great many calutron separators within the field of a single magnet, the largest in existence, with circular pole faces 15 feet across, and with an air gap of 6 feet. This magnet had been built for the giant cyclotron at Berkeley but was converted and used in the development of the calutron. In the final production system a number of magnets, each containing many separators in its air gap were set up at the Clinton works and fed with power from the TVA system.

Although the report makes no mention of the fact, newspaper reports indicate that 28 million pounds of silver were borrowed from the U. S. Treasury to wind the coils for these magnets, because copper was not available. The silver also had lower losses, and would be recoverable at the end of the project.

Another electronic device for separation is the isotron. This tube employs the principle of the klystron, bunching ions by velocity modulation of the ionic beam. A source of positive ions (an area larger than the slit of the calutron, and hence carrying more material) is accelerated to high velocity by application of a steady high-voltage electric field. Since the ionic velocity is inversely proportional to the square root of the mass, the U^{235} ions reach higher velocities than the U^{238} atom. Superimposed on the steady accelerating voltage is a sawtooth wave of voltage which causes the ionic velocity to be modulated, and the stream of ions is thus bunched in the same manner as the electron beam in a klystron. Since the two forms of ions are traveling at different speeds, the U^{235} and U^{238} bunches occur at different positions along the axis of the tube. Hence separation of the ions is achieved along the ion beam.

To collect the U^{235} ions, it is necessary to transmit them to a collector plate without at the same time collecting the U^{238} bunches. The separation is carried out by a transverse electric field, synchronized with the sawtooth bunching field, and timed so as to deflect the U^{238} bunches as they arrive. The field is cut off as the U^{235} bunches pass, hence this component of the ion beam passes undeflected to a collector plate. While this device produced partially separated samples of U^{235}, it was not deemed as useful as the other separation methods and its large-scale applicability to large scale processes was not investigated.

Another electronic means of separation, based on the principle of the magnetron, was investigated but not developed to the point of large scale use. This device, known as the ionic centrifuge, operates on the principle of whirling an ionic beam in a transverse magnetic field.

Production of Plutonium

The reaction producing plutonium has already been described. In the production of plutonium the problem was to achieve a controllable chain reaction such that plutonium could be produced at a continuous rate from uranium metal without danger of an atomic explosion. The solution to this problem is a structure known as a chain-reacting pile, consisting of rods of uranium sealed in aluminum jackets and inserted in a large block of graphite. The heat produced in the reaction is removed by passing water through the pile, between the uranium rods and the graphite. Control rods of inert material are inserted in the graphite and moved in or out of the pile by remote control so that the neutron production may be speeded up or slowed down as the reaction proceeds. The positions of the control rods are adjusted automatically so that the neutron multiplication factor remains at unity. The chain reaction is thereby stabilized and proceeds at a constant rate, and the U^{238} in the uranium metal is continuously transformed into plutonium.

Two processes occur simultaneously in the pile: the U^{235} present undergoes fission in a chain reaction (the amount of uranium present is large enough in the presence of the graphite to support such a reaction) and the fission of the U^{235} provides a continuous supply of fast neutrons. These are slowed down in the graphite. Some of these slow neutrons enter the remaining U^{235} to maintain the chain reaction, while others, of suitable speed, are absorbed by the U^{238} present, thereby initiating the plutonium reaction previously described. As the reaction proceeds, the U^{235} is transmuted to a number of fission products, the U^{238} yields an increasing amount of plutonium, and a great deal of heat is liberated. When the reaction has proceeded to a safe limit, the control rods are manipulated to stop the reaction and the aluminum jackets, now containing U^{238}, U^{239}, plutonium and fission products, are removed from the pile and transported to the chemical separation plant.

The separation is accomplished in huge concrete troughs or canyons. The contents of the aluminum jackets are dissolved and the plutonium precipitated from the solution in the form of an oxide salt. By successive precipitations of different oxides, the plutonium is removed from the uranium as well as from the fission products, which comprise some 20 elements, all violently radioactive. The separated plutonium oxide is then reduced to produce the pure metal. Three piles, operating at a power level in the hundreds of thousands of kilowatts (a measure of the heat produced by the reaction) were in operation during the summer of 1945 at the Hanford plant.—D. G. F.

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CRACK DETECTOR FOR

Cracks in metal wire, bars, and tubing, passed through the field of the inductor of one of two oscillators, change the beat frequency. Beat voltages are rectified to operate a meter, a neon tube and a relay. Cracks are marked by paint sprayer when relay closes

By JOHN H. JUPE
Enfield, England

DETERMINATION of the quality of a metal product has frequently been a laborious process where it has been necessary to rely on fatigue tests and the study of microsections of samples. Such procedure is slow and costly and conducive to waste in production. A solution to the problem of production testing, at high speed, for cracks in metal wire, tubing and bars is based on the electrical characteristics of the metal under test. A compact electronic instrument has been designed for this purpose by Salford Electrical Instruments, Ltd., a subsidiary of General Electric Company, Ltd., of England.

Basic Principle

It is well known that the depth of penetration of r-f current in a conductor is related to frequency, permeability and conductivity. The decay of current toward the center of the conductor is exponential and can be compared to a transmission line, where the attenuation constant gives a measure of the decay in current at the end. In practice, where depth is concerned, it is sufficiently accurate to take the depth of current as being the point where attenuation occurs to the extent of one neper (8.686 db).

Depth of current, in thousandths of an inch, for one neper loss, is given by the formula

$$D = 1.98\sqrt{\frac{1}{f\mu\sigma}}$$

where f = frequency
μ = permeability
σ = resistivity in microhms per cu cm

Figure 1 shows a graph which has been calculated for copper at 60 F, steel at 60 F and steel at the Curie point. Of course, the depth of current will vary with μ and σ but in general, variations in magnetic materials are sufficiently narrow to assume a uniform depth of current at one frequency for low values of magnetic field strength. Slight variations of conductivity (the only variable in the case of non-magnetic materials) cause little difference in the depth of current, which is proportional to the square root of the conductivity.

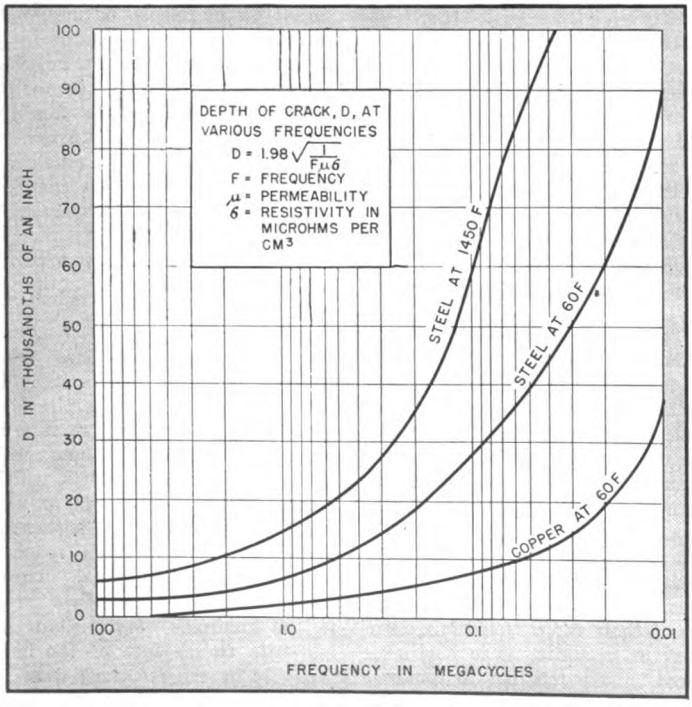

FIG. 1—Depth *D* of crack is graphically represented as a function of frequency

Simulates Transformer

The above theory is applied in the new instrument by first arranging a coil to induce eddy currents in the sample at right angles to the axis. Then, if the frequency is such that the current penetration is deeper than the deepest crack, the effect will be to provide a short-circuited turn and an effective variable resistance in the coil, which will act like the secondary of a transformer transferring its load to the primary. If the oscillator frequency is now measured, using a

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PRODUCTION TESTING

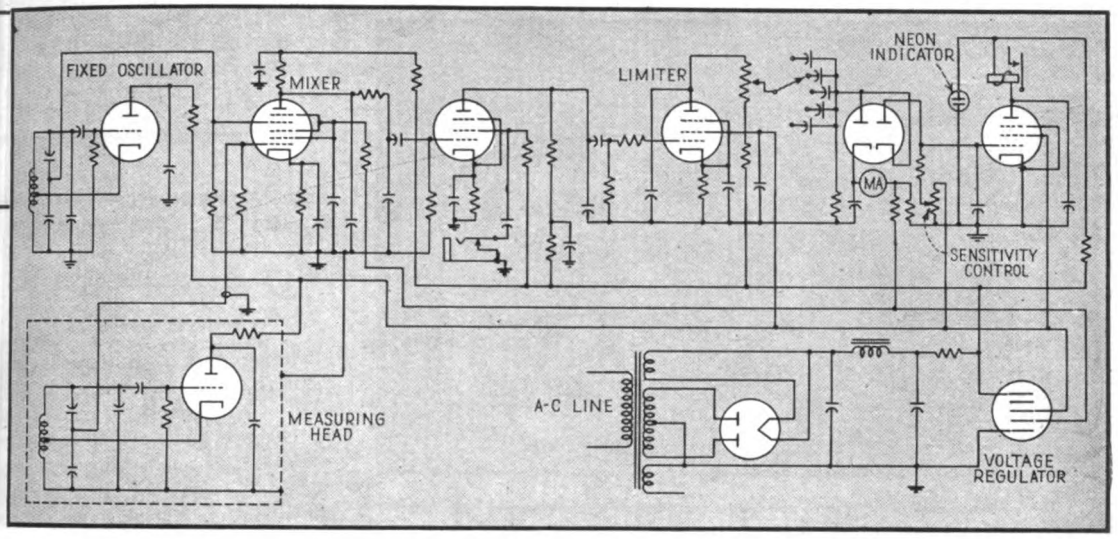

FIG. 2—Complete circuit of the radio-frequency crack detector. Materials to be tested are introduced into the field of the inductor in the measuring head. Cracks in the material act like shorted turns, changing the inductance and hence the beat frequency produced in the mixer

crack-free sample to act like a short-circuited turn, the frequency will be found to change because of the change in the oscillator inductance when a crack enters the field of the coil.

A portion of the oscillator voltage is taken and passed through filter circuits and an indicating instrument so that a variation in frequency, caused by a crack, has the effect of causing a large variation in output voltage as shown on a meter. To avoid worker fatigue and to insure against missing short flicks of the meter pointer a neon lamp flashes at the same time.

The fact that cracks are rarely uniform in depth for more than a fraction of an inch, or may be full of oxide, has not been found to be serious in operation of the instrument but should be borne in mind when attempting to take a micro-section on a sample.

The crack detector is capable of giving indications of cracks from 0.0005 to 0.25 inch deep. The lower limit is set, not by the apparatus but by the surface condition of the sample. Material from 0.125 to 0.5 inch and from 0.5 to 6.0 inches in diameter can be tested in two standard instruments.

Figure 2 shows a schematic of the equipment. The method of operation is as follows: The sample to be tested passes through the inductance of an oscillator in the measuring head, which is beating against a fixed frequency oscillator. The resultant output is mixed in the pentagrid tube. Audio output is amplified by the first stage and passed into a limiter, which feeds a square-wave output to the diode frequency-measuring circuit. Another diode takes the rectified d-c and operates a neon tube and relay in the anode circuit of the final pentode. The function of the neon tube is to provide a quick indication of a crack when material is being tested at a high speed.

The neon tube can be made to fire at any predetermined depth of crack by adjustment of the potentiometer in the grid circuit of the pentode. To make the operation entirely automatic, the relay in the anode circuit of the last pentode operates a small compressed-air paint sprayer, which marks the faulty material over the crack. The relay is adjusted to close when the neon tube fires.

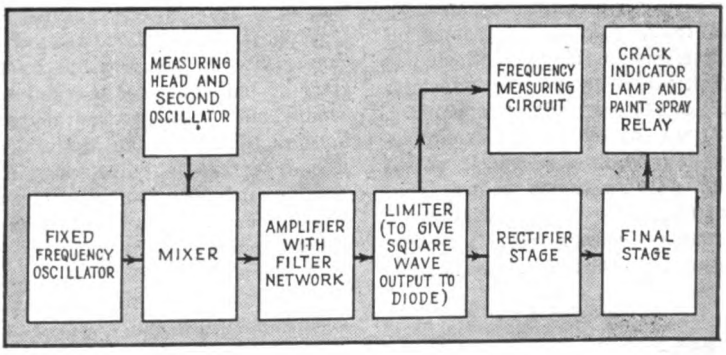

FIG. 3—Inter-relation of circuit functions is illustrated by this block diagram of the crack detector

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Design of STABLE

By JOHN B. MOORE
RCA Communications, Inc.
New York, N. Y.

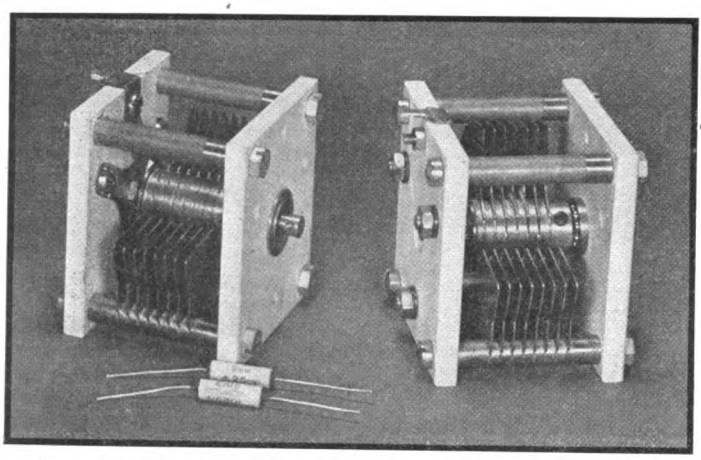

FIG. 1—Examples of variable capacitors designed to compensate the temperature coefficient of coils in heterodyne oscillators, and midget ceramic capacitors used to compensate small fixed values of capacitance in the tuning capacitors

THE PRINCIPLES, factors, and methods discussed herein have been successfully applied in the design of heterodyne oscillators for certain commercial equipment. Variation of frequency with temperature can be brought down to a consistently low value of less than $10/10^6$/°C (ten parts per million per degree centigrade) over the normal tuning range of something more than 2 to 1 in oscillator frequency, without resort to special treatment of individual oscillator assemblies, by employing a carefully designed variable capacitor like those shown in Fig. 1.

The electrical circuit of the heterodyne oscillator under consideration employed a conventional Hartley oscillator arrangement, as shown in Fig. 2. The frequency-determining elements that are affected by temperature are (1) the inductance coil L, (2) the variable capacitor C, (3) the interelectrode capacitances in the tube, its base, and its socket, and (4) resistance values, stray capacitances from wiring to grounded chassis, etc. The main elements will be treated separately.

Inductance Coil

For high-frequency oscillators to cover a receiver range of from about 4 mc to 25 mc, the coil normally will be of bare copper wire wound on a form made of insulating material. Except where special means are employed to wind the wire under tension and to anchor both ends in such a manner as to retain this tension, the wire normally will be sufficiently loose on the form so that its expansion and contraction is essentially independent of that of the insulating form. The diameter of the copper-wire coil therefore has a temperature coefficient of expansion of plus $14/10^6$/°C. The resultant variation of inductance is plus $28/10^6$/°C and that of frequency is minus $14/10^6$ °C. Lengthwise expansion and contraction of the insulating form has a much lesser effect, and ordinarily may be disregarded.

While it is possible to reduce or compensate the temperature coefficient of inductance of the coil assembly, such methods generally are not practical for quantity production. They are apt to be fussy, expensive, and none too reliable over a long period of time and under usual conditions or procedures of maintenance and repair. It therefore seems preferable to make a good substantial and low-loss coil, preferably on a ceramic form, having a reliably uniform and constant temperature coefficient of inductance. As stated above, that should be about $28/10^6$/°C, giving a frequency variation of minus $14/10^6$/°C.

Variable Capacitor

The variable capacitor is the element that can be expected to give most of the trouble. Various types tested have given overall frequency variations vs temperature that vary widely in magnitude. In some cases the variations are plus and in some cases they are minus. The major problem, therefore, is to obtain a design of variable capacitor that can be produced under factory conditions and yet will have a uniform temperature coefficient of capacitance of the desired sign and magnitude.

Instead of attempting to analyze any specific type of commercially available capacitor of conventional construction, let us point out the basic factors and solutions. Their practical application will depend upon the specific design problem or equipment.

In Table I are listed approximate values of the linear coefficients of thermal expansion, expressed in parts per million per degree centigrade, for various materials that enter into the construction of variable capacitors.

Plate Area Problem

The most obvious fact is that the area of the interleaved metal plates of the variable capacitor will increase with increasing temperatures, and vice versa. For aluminum plates, the increase in area, and therefore in capacitance, would be approximately $48/10^6$/°C. This would add to the change in oscillator frequency produced by the coefficient of inductance of the coil. Obviously this is not what is needed. We should have a capacitor that will provide a negative rather than

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HETERODYNE OSCILLATORS

Methods of eliminating, minimizing, or compensating the temperature-produced changes that affect frequency. Overall oscillator stability of better than 10 parts per million per degree C over a 2-to-1 tuning range at 24 mc can be obtained in production

a positive temperature coefficient of capacitance. This then will compensate for the inductance variation.

Further inspection of the tabulated figures will show that Invar —a special 36 percent Ni nickel-steel—has an almost negligible coefficient of thermal expansion. Invar, copper-plated to provide good electrical conductivity, would seem to be the metal to use for the plates of the variable capacitor. This is a satisfactory partial answer, provided such copper-plated Invar plates are supported at essentially one point—as in the rotor assembly. If supported at two or more points in a framework composed of other metals or of insulating materials, the difference in coefficients of thermal expansion will cause such plates to buckle and thereby change the spacing between, say, stator and rotor plates. This buckling is very slight, but we are dealing in terms of parts in a million. That means, in this case, millionths of an inch.

If we make the rotor plates of Invar, and so arrange the stator plates that their expansion toward the central shaft is compensated by their being bodily shifted away from the central shaft because of expansion of the supporting end plates, we find that the area of dielectric (air) included between the interleaved rotor and stator plates then remains constant. The method of accomplishing this will depend on the general mechanical design of the variable capacitor. Reference to Table I will show that one possible combination is to have supporting end-plates of Isolantite and stator plates of 42 percent Ni nickel-steel, because these two materials have nearly identical coefficients of thermal expansion.

Plate Spacing Problem

We now have an area of active air dielectric which, instead of varying with temperature, remains constant. This is a step in the right direction. But how about the thickness of the dielectric—the spacing between rotor and stator plates? If that varies in either an undesirable or an unpredictable manner with variations in temperature, the overall temperature coefficient of capacitance still will not be what is required.

In order to compensate for the plus temperature coefficient of inductance of the coil, the coefficient of capacitance of the variable tuning capacitor should be negative. This can be attained by mounting rotor plates and stator plates on, let us say, brass supporting and spacing members. A built-up pile of plates and spacing washers is undesirable, because of the various uncertainties introduced by such a construction. A preferable design, from the viewpoint of reliability and reproduceability, is one in which the plates—Invar for rotor and possibly 42 percent Ni nickel-steel for stator—are soldered into annular grooves machined into the surface of the brass sleeve (rotor) or pillar (stator) used as a supporting and spacing member. This insures that the linear expansion of the rotor assembly and of the stator assembly, in the direction of the axis of the main shaft, will be identical. Spacing between the rotor and stator plates thus is maintained uniform, regardless of temperature variations, throughout the length of the rotor and stator assembly. These brass supporting members produce a uniform linear expansion of approximately 18/10⁶ /°C. This uniformly increases the air spacing between rotor and stator plates by a coefficient greater than that of the brass itself, because of the lesser coefficient of expansion of the sheet stock of which the rotor and stator plates are made. The net coefficient obviously depends upon the coefficients of the several metals used, and also upon the ratio of metal plate thickness to air gap.

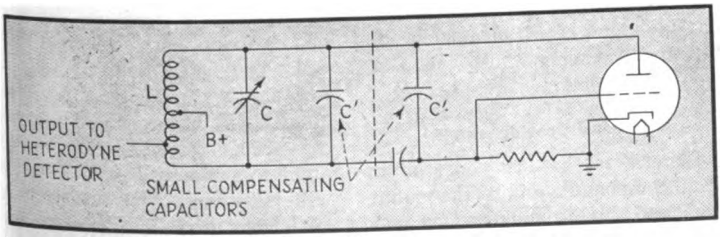

FIG. 2—Hartley oscillator arrangement employed in the heterodyne oscillator under consideration

Example of Capacitor Design

A numerical illustration will aid in understanding the foregoing. Assume a rotor plate of Invar having a thickness of 30 mils (0.030 inch), a stator plate of 42 percent Ni

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nickel steel having a thickness of 30 mils, and an air gap of 40 mils. This gives a total spacing between centers, of either rotor or stator plates, of 140 mils (15 plus 40 plus 30 plus 40 plus 15). Expansion of the brass is $0.140 \times 18 \times 10^{-6}$ inch per degree C. Expansion in thickness of a single rotor plate is approximately $0.030 \times 1 \times 10^{-6}$. That of a single stator plate is approximately $0.030 \times 7 \times 10^{-6}$ inch per degree C. The increase for two air gaps totalling 40 mils is, therefore, $2.52 - (0.08 + 0.21)$ or 2.28×10^{-6} inches per degree C. This gives a resultant coefficient of $28.5/10^6$/°C instead of only $18/10^6$/°C which might erroneously have been expected.

The resulting thermal coefficient of capacitance is $-28.5/10^6$/°C. Note that this is almost numerically equal to the thermal coefficient of inductance of the coil, but is opposite in sign. The two therefore will compensate each other.

In order to insure the above action, it is essential that the uniform linear expansion of rotor sleeve and stator pillar start from a common reference point or plane. If the brass pillars supporting the stator plates start from a common end frame or insulating plate, but the brass sleeve carrying the rotor plates is fastened to a steel main shaft by means of a setscrew located about ¼ inch from the end frame or insulating plate, the differential in expansion between ¼ inch of brass (stator support) and ¼ inch of steel (rotor shaft) upsets matters. The trouble must be remedied by the insertion of ¼ inch of steel in the brass pillars that support the stator.

That takes care of the variable portion of the tuning capacitor. In addition, though, there generally are small fixed values of capacitance having both air and solid dielectric. Published data show that the dielectric constants of porcelains, Isolantite, etc, have extremely high thermal coefficients. These may run as high as $500/10^6$/°C or more. A very few micromicrofarads of stray capacitance through such a solid dielectric can, therefore, introduce a serious variation at the lower values of total capacitance used at the high-frequency end of the tuning range.

TABLE I. LINEAR COEFFICIENTS OF THERMAL EXPANSION

Material	Coefficient
Aluminum	$24/10^6$/°C
Brass	$18/10^6$/°C
Copper	$14/10^6$/°C
Invar (36% Ni Steel)	$0.9/10^6$/°C
Isolantite	$7/10^6$/°C
Nickel-steel (42% Ni)	$7/10^6$/°C
Steel	$10/10^6$/°C

This is most satisfactorily taken care of by the addition of a small fixed capacitor, such as a Ceramicon, which will give the required micromicrofarads compensation—say 1000×10^{-12}—per degree Centigrade.

It is only by such separate treatment of the variable and fixed portions of the main tuning capacitor that the desired result can be most closely approximated in a consistent and reliable manner. It will be apparent that a combination of proportional compensation and fixed compensation—for the variable and the fixed portions of the total tuning capacitance—can not provide perfect compensation of the variation of inductance of the coil. The amount of fixed capacitance compensation to be used, therefore, is somewhat of a compromise. Actually, however, the frequency of the complete oscillator can be compensated to within a few parts per million per degree C over a frequency range of two to one.

Tube and Miscellaneous Capacitances

Inter-electrode capacitances in the oscillator tube, capacitances in tube base and socket, and other miscellaneous stray capacitances in the oscillator circuit and to ground generally have an overall temperature coefficient of capacitance that is plus in sign. They therefore are compensated by use of a small compensating capacitance that provides capacitance compensation of perhaps -1000×10^{-12} $\mu\mu$f per degree C. The value required must be determined experimentally for any particular design.

General Considerations

General mechanical construction of all components and of the mountings and wiring must be of good design and rigidity. Clearance between high-potential r-f points in the circuit and ground should be reasonably large.

In special experimental assemblies it has been possible to obtain a temperature coefficient of frequency of some $2/10^6$/°C or less, over a frequency range of approximately two to one in the high-frequency region up to 24 mc.

Production units employing the oscillator design described can be expected to have temperature coefficients of frequency that will be consistently less than $10/10^6$/°C.

Applications

In radio receiving equipment intended for commercial use, such as in transoceanic radiotelegraph services, the problem of frequency stability is becoming of greater and greater importance as channel widths and spacings are reduced in an attempt to provide the large number of separate communication channels desired. In some cases, crystal oscillators have been employed. These are, however, of use only for reception on a few fixed frequencies. Where it is necessary to be able to tune in any one of a large number of signals quickly, over a wide range of frequencies, the simplest solution appears to be the use of a highly stable oscillator of the continuously variable type. It is then that design considerations aimed at reducing the temperature coefficient of frequency of the r-f heterodyne oscillator become questions of major importance.

As an example, consider the case of operation at an r-f carrier frequency of 10,000 kc and with an i-f pass band of 1 kc total or plus and minus 0.5 kc. If the frequency of the local heterodyne oscillator drifts 0.5 kc, which at 10,000 kc is only 50 parts per million, the signal will be at the edge of the pass band of the receiver. An uncompensated oscillator may easily drift this much with a change in ambient (room) temperature of only one degree C or approximately two degrees F. A well-constructed oscillator having a low temperature coefficient of frequency will, however, permit of five to ten times as great a change in the ambient temperature. It therefore will take care of the temperature variations normally expected in any installation at which operating personnel are in attendance.

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AUTOMATIC FADER

By DAN HUNTER *Chief Engineer, Station WMAL Washington, D. C.*

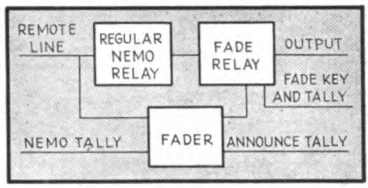

FIG. 2—Essential elements of the automatic fader system

THE device to be described automatically fades a program either completely or partially in or out, at predetermined rates, without the use of motors. The only moving parts consist of three relays, and individual fade-in and fade-out timing is easily adjusted.

The automatic fader is used to fade the nemo, a remote or network program for a local broadcast, or to join a remote or network program already under way. In the studio, it is also convenient for announcing a remote program. These operations involve strict cooperation between the master-control operator and the announcer unless the program is routed through a studio having a studio operator. This close cooperation demands the type of attention very difficult to achieve in any master control.

Circuit

The automatic fader was designed to operate from the nemo and announce tally lights plus an installed fade key and tally. As shown in Fig. 1, the fader is essentially an amplifier adjusted for zero gain, with time-delayed bias for control. The amplifier tube is biased to cut-off for complete fade-out, at an intermediate point for partial fade-out or in, and normal for complete fade-in. The bias is obtained from the two potentiometers in the bleeder circuit.

Two variable timing controls are included (slotted shaft for screwdriver adjustment), one for complete fadeout and one for complete fade-in. Timing of a complete fade is adjustable from 1 to fifteen seconds. The timing for the background level or partial fade is fixed at approximately two seconds.

The 6C5 is operated at a plate current of 0.5 to 0.6 ma to obtain a smooth fade. This quiescent point places the operation of the tube slightly above the point where the amplification begins to vary. This imposes a definite limitation on the maximum permissible input level at which the fader may be operated without distortion. The input is 10,000 ohms bridging, while the output is 500 ohms. The fader and its power supply were mounted on 3.5-in. rack-mounting panels.

At WMAL, the fader is in the nemo circuit, as shown in the block diagram of Fig. 2. The input of the fader is bridged across the nemo line and the fade relay switches either the nemo or the fader to feed the equipment. This switching can be done any time during a program provided a relay with grounding resistors is used. At WMAL an Automatic Electric relay is used, with 50,000-ohm resistors from all contacts to ground.

The relay L-2 which gives complete fades obtains its battery from the nemo tally light. This was done so that the fader would always be ready to perform. If the nemo is down, the fader is ready to fade in and vice versa.

The partial fade or background-level relay L_1 connects to the battery supplying the announce tally through a contact on relay L_2. This allows a background level only when both announce and nemo are set up. Since the tally lights and set-up buttons are on the announcers switching, console, (delite), the fade key and tally were also placed on the delite. This enables the announcer to completely fade in or out a program or announce over a background level without an operator.

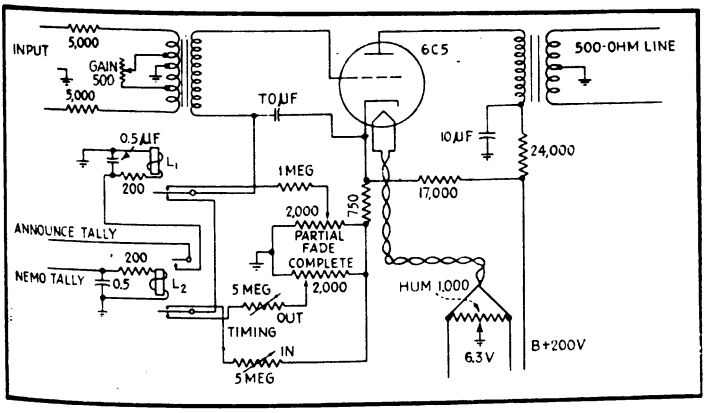

FIG. 1—Vacuum-tube circuit for complete or partial automatic fading of programs

Operation

If a fade is desired, the fade key is turned on; the fade tally gives indication. When nemo is released, the program is faded out, or if nemo is set up, the program is faded in. If announce is set up at the same time, then the program is either faded in or out but to a background level.

It was found that a partial fade of 10 db of tone (500 cycles) gave a good background level. The level is adjustable to −58 db when using the circuit shown in Fig. 1.

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MICROWAVE

Propagation characteristics of the super high frequencies are ideally suitable for short-range communications services. Systems can effectively use highly directional antennas and low power. Stability may be as good as in any other part of the radio spectrum. Transmitter and receiver design is discussed

By FREDERIC A. JENKS
Research Laboratories
Sperry Gyroscope Co., Inc.
Garden City, N. Y.

THE WAR stimulated radio progress to such an extent that many new communications services are on the verge of becoming a commercial reality. A large number of applications will involve short-haul or line-of-sight distances. It is conceivable that there might be thousands of microwave links within a small area, such as a county. To prevent interference with each other, as well as with other services, the correct use of frequencies is as important as the proper design of circuits used in the new equipment.

Recent electronic developments in the ultra high frequency (uhf) and super high frequency (shf) regions have provided sufficient technical progress to open up these bands for practical use. In the past, most equipment which operated at such high frequencies was considered experimental and was often crudely built and difficult to adjust. Modern equipment designed for the microwaves is ruggedly constructed, easy to adjust, and utilizes circuits which perform favorably by comparison with those used in lower frequency apparatus.

When studying channel space available for the new services it is interesting to examine Fig. 1A. This chart of the radio frequency spectrum was drawn on a logarithmic basis. Plotting in this manner provides a convenient way of visualizing all channels with equal clarity, but it does not present an adequate picture of the tremendous portion of the spectrum which has been made available by recent microwave developments. In Fig. 1B the same amount of spectrum has been replotted on a linear basis and it is immediately apparent that the new high frequency regions represent the major portion of the spectrum.

At first glance it might appear that such an expanse of new frequencies will provide sufficient space for all the channels which might be required for many years to come, especially for line-of-sight transmissions. This may be true if the new bands are properly utilized. It must be remembered, however, that many of the services to be operating in the uhf and shf bands will require wide bandwidths, possibly in the order of 20 megacycles or more. It only takes 50 of these 20-megacycle channels to fill a 1000-megacycle block of frequencies, and there are not too many of these blocks available.

Fortunately, such short wavelengths allow the use of mechanically practical antenna structures that provide sharply directional beams for point-to-point communications and relay links, and minimize interference with other services outside the coverage area of the beamed radiation. This directivity together with freedom from atmospheric interference allows the

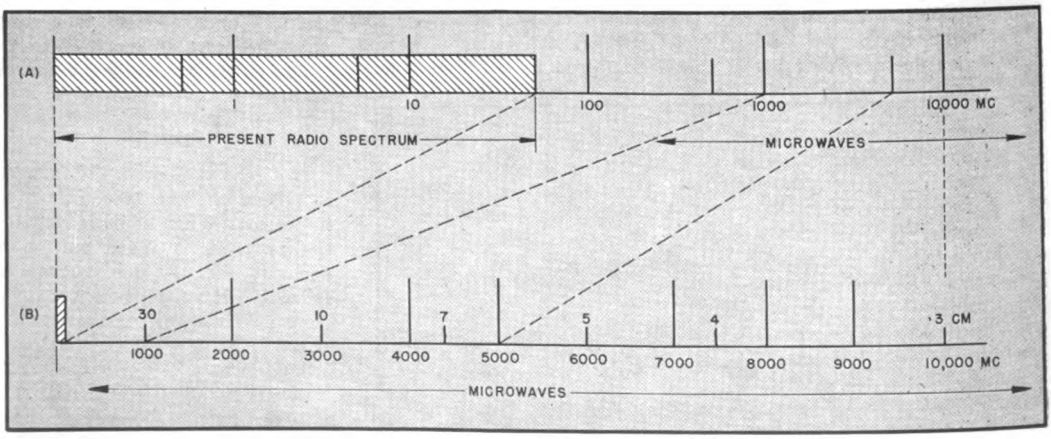

FIG. 1—(A) The radio spectrum, plotted on a logarithmic basis, presents an inadequate picture of the space available in the microwave region for postwar development. (B) When the spectrum is plotted linearly the importance of the super high frequencies becomes at once apparent

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use of surprisingly low transmitter powers to accomplish reliable communication.

Services which can take advantage of this type of communication might include the following: program relay links, pickup-to-studio circuits, railroad communications, emergency short range services, aircraft aids to navigation, and domestic airport traffic control, just to mention a few.

General Considerations

Adjacent fixed station microwave systems can use the same frequency bands in many instances by taking advantage of the fact that even radiation having a low vertical angle is eventually lost in space, passing through the ionosphere region rather than being reflected back to earth. This condition is illustrated in Fig. 2A. Notice that the beams of adjacent stations in the two separate systems *A* and *B*, pass over each other, and that the systems therefore do not interfere. If directivity is used in the horizontal plane, as shown in Fig. 2B, many systems such as those represented at *C*, *D* and *E* may be located in the same area without causing interference to each other. For simplicity of illustration one-way systems are shown. Two-way systems are obviously equally practical.

While ground stations cannot receive radiation passing over them, aircraft in the vicinity will be subject to interference. If many ground installations are in operation, aircraft will be in a beam from some station nearly all the time. Consequently, the frequencies used for aviation services should be removed from those used by point-to-point ground systems. Airplane-to-ground communications will require special consideration. With a large number of airports in the same vicinity it is quite necessary, unlike point-to-point ground services, that they operate on different channels. Aircraft flying at high altitudes will be exposed to radiation from airports, other aircraft, weather stations, aids to navigation, and possibly other ground services. To be certain that microwave equipment carried in the airplane is receiving the desired signals, and not unwanted radiations, many frequency channels will have to be provided. From 50 to 100 closely spaced aircraft channels may be the common thing a few years hence, especially on airplanes flying the international routes.

Realizing these facts, it becomes apparent that the tremendous frequency band occupied by the new wavelengths will not provide an unlimited number of channels even if many communication systems are sharply beamed. However, by employing frequency stability tolerances which are comparable to those used on the lower frequency bands, channels can be placed close enough together so that none of the spectrum is wasted. Techniques are now available whereby stability on the microwave bands can be as good as that in any other part of the radio spectrum.

Transmitter Power

Electromagnetic energy radiating from a point source in space produces a power per unit solid angle of

$$p'_{d\omega} = \frac{P}{4\pi} \text{ watts} \qquad (1)$$

where P is the total power radiated from the point source. However, since dipoles are generally used as the standard of comparison, the radiated power from a dipole in the direction of a receiver which lies in a plane perpendicular to and centered upon the dipole is given by

$$p_{d\omega} = \frac{3P}{8\pi} \text{ watts per unit solid angle} \qquad (2)$$

where the increase of 3/2 is due to the directional characteristics of the dipole.

Since the equivalent area of a dipole[1] is given by

$$A_d = \frac{3\lambda^2}{8\pi} \qquad (3)$$

it is capable of absorbing an

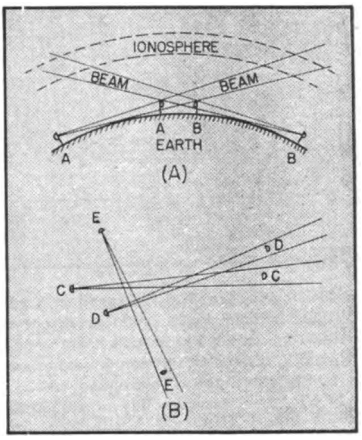

FIG. 2—(A) Because the microwaves normally penetrate the ionosphere and are lost beyond it, and are not reflected back to earth, transmissions between the two stations in system *A* and the two stations in system *B* will not ordinarily cause mutual interference. (B) Transmissions sharply beamed in the horizontal plane permit the operation of a plurality of adjacent stations such as those constituting systems *C*, *D* and *E*, without mutual interference

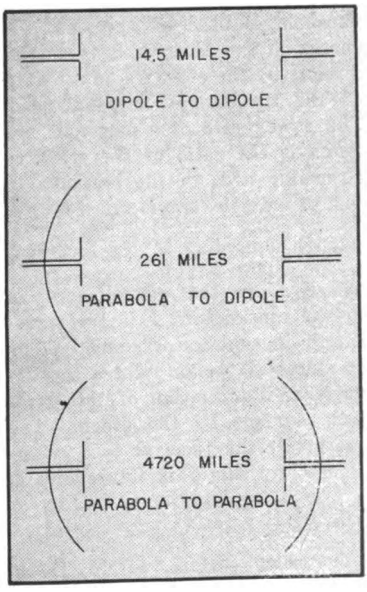

FIG. 3—Theoretical distances which may be covered by point-to-point microwave systems using various transmitting and receiving antenna combinations are shown in miles. In all three cases illustrated transmitter power is 0.1 watt, wavelength is 10 cm, transmitted bandwidth is 200 kc, and the receiver noise figure is 15 db or 31.6-to-1 on a power basis. Parabola area is 6000 square centimeters, giving an effective power gain of 325

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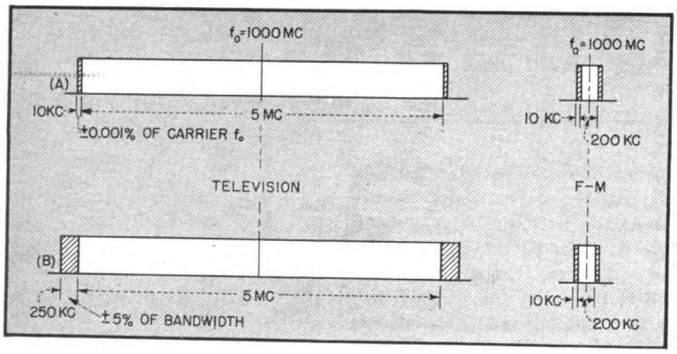

FIG. 4—(A) Stability expressed as a percentage of carrier frequency, showing how 10-kc latitude which might represent a standard for an f-m system operating on 1000 mc would be difficult if not impossible to achieve in connection with a television transmitter operating on the same frequency but requiring greater bandwidth. (B) Stability expressed as a percentage of bandwidth, illustrating the practicability of standards based upon such a scheme

amount p_r of the radiated power per unit solid angle at a distance r, and is given by

$$p_r = \frac{3P}{8\pi} \times \frac{3\lambda^2}{8\pi} \times \frac{1}{r^2} = \left[\frac{3}{8\pi}\right]^2 \frac{P\lambda^2}{r^2} \text{ watts} \quad (4)$$

where both λ and r are given in centimeters. This equation gives the energy at a distant receiver for a system using dipoles for transmitting and receiving.

If a directional antenna such as a parabola is used at one end, the energy at the receiver is increased directly by the effective power gain of the directional antenna used. The power gain of a parabolic antenna is the ratio of the effective absorbing area of the parabola to that of a dipole, and is given by

$$G = 0.65A/(3\lambda^2/8\pi) = \frac{8\pi}{3}\frac{A}{\lambda^2} \times 0.65 \quad (5)$$

where A is the mouth area in square centimeters, λ is the wavelength in centimeters, and 0.65 is an empirical factor related to nonuniform illumination of the parabolic surface by the dipole. The energy at the receiver is now increased by this gain figure and is

$$p_r = \left[\frac{3}{8\pi}\right]^2 \frac{P\lambda^2}{r^2} \times \left[\frac{8\pi}{3}\frac{A}{\lambda^2} \times 0.65\right] = 0.0775\frac{PA}{r^2} \text{ watts} \quad (6)$$

With a parabola at each end of the system, the ability to concentrate the energy in the desired direction is further enhanced, and the receiver power then becomes

$$p_r = \left[0.0775\frac{PA}{r^2}\right] \times \left[\frac{8\pi}{3}\frac{A}{\lambda^2} \times 0.65\right] = 0.423\frac{PA^2}{r^2\lambda^2} \text{ watts} \quad (7)$$

In all of the above cases the transmission was assumed to be through free space, without any nearby objects to disturb the path of the radiated energy. In applications such as point-to-point fixed systems this ideal condition will not be realized. A scattering effect caused by the energy passing over the ground at grazing incidence will reduce the signal at the receiver. Scattering caused by trees, houses, and other objects may be appreciable, and should be taken into account when determining transmitter powers for such propagation conditions.

For a receiver signal-to-noise ratio equal to unity, the available signal power at the receiver should be equal to the theoretical noise power of the receiver times its noise figure. The noise figure is defined[3] as the ratio of the available signal-to-noise ratio at the signal source terminals to the available signal-to-noise ratio at the receiver output terminals.

$$F = (S_i/KTB)/(S_o/N_o) = (S_i/KTB)(N_o/S_o)$$

where K = 1.38 x 10^{-23} joules per degree Kelvin
T = 300 degrees Kelvin
B = effective bandwidth in cycles per second
F = noise figure of the receiver
S_i = available signal power at signal source terminals (antenna matched)
S_o = available signal power at receiver output
N_o = available noise power at receiver output

Solving for the available signal power at the signal source (antenna) terminals, gives

$$S_i = \frac{S_o}{N_o} FKTB \text{ watts} \quad (9)$$

To make the signal-to-noise ratio at the output equal to unity, the available signal power delivered by the receiving antenna circuit must be equal to

$$S_i = FKTB \text{ watts for } \frac{S_o}{N_o} = 1 \quad (10)$$

Now let us compare the range of several systems in which the antenna power, transmitted bandwidth, and noise figure are the same but the antennas used are different, as illustrated in Fig. 3. It will be assumed that the transmission is over a line-of-sight path without grazing incidence. The following conditions will be alike in each case:

P = 0.1 watt transmitter power
B = 200 kilocycles transmitted bandwidth
F = 15 db = 31.6 to 1 (on power basis)
λ = 10 centimeter wavelength = 3000 mc
A = 6000 square centimeters, parabola area to give an effective power gain of about 325

For a system using a dipole at each end, Eq. (4) equals Eq. (10) for maximum range.

$$p_{min} = \left[\frac{3}{8\pi}\right]^2 \frac{P\lambda^2}{r^2} = FKTB = 2.61 \times 10^{-14}$$

$$r^2 = \left[\frac{3}{8\pi}\right]^2 \frac{P\lambda^2}{FKTB} = (0.0142)\frac{(0.1)(100)}{2.61 \times 10^{-14}}$$

$r^2 = 5.44 \times 10^{12}$
$r = 2.33 \times 10^6$ cm = 14.5 miles range

For a system using a parabola at one end and a dipole at the other, Eq. (6) equals Eq. (10) for maximum range.

$$p_{min} = 0.0775\frac{PA}{r^2} = FKTB = 2.61 \times 10^{-14}$$

$$r^2 = 0.0775\frac{PA}{FKTB} = 0.0775\frac{(0.1)\,6000}{2.61 \times 10^{-14}}$$

$r^2 = 17.85 \times 10^{14}$
$r = 4.20 \times 10^7$ cm = 261 miles range

For a system using a parabola at each end, Eq. (7) equals Eq. (10) for maximum range.

$$p_{min} = 0.422\frac{PA^2}{r^2\lambda^2} = FKTB = 2.61 \times 10^{-14}$$

$$r^2 = 0.422\frac{PA^2}{\lambda^2 FKTB} = \frac{(0.422)(0.1)(6000)^2}{(10^2)\ 2.61 \times 10^{-14}}$$

$r^2 = 0.582 \times 10^{16}$
$r = 0.761 \times 10^8$ cm = 4720 miles range

The use of parabolas increases the system range by the square root of the product of the effective antenna gains at each end. The 4720 mile range of the last calculation is used for illustration purposes only, and is obviously not realizable on the surface of the earth.

Frequency stability can be de-

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fined as the amount of random frequency variation in an unmodulated carrier, compared to the carrier frequency on a percentage basis. Since the various radio services such as television, f-m and a-m broadcasting, and telegraph, require widely different bandwidths for the transmission of their intelligence, it seems reasonable that they should require different carrier frequency stabilities also.

Consider a television channel five megacycles wide and an f-m channel 200 kilocycles wide. If both of these services had the same stability, it would probably be the narrower of the two which would determine what the stability should be. Suppose the allowable carrier drift of the f-m channel was ± 10 kilocycles. It would be folly to expect the television people to keep their transmitter carrier to within ± 10 kilocycles, as indicated in Fig. 4A, when their receiver bandwidths vary more than that in production. A more logical way of assigning a stability figure to a given service would be to base the allowable random carrier variation upon a certain percentage of the transmitted bandwidth. For example, if the stability figure in the above illustration was ± 5 percent of the bandwidth, then the f-m carrier would have to be maintained within ± 10 kilocycles, as before, but the television carrier would be allowed a ± 250 kilocycle drift, as shown in Fig. 4B.

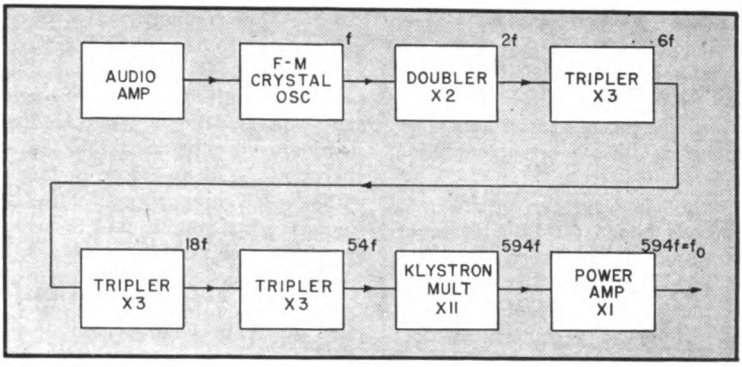

FIG. 6—Block diagram of a microwave transmitter employing a crystal oscillator for frequency control, a conventional doubler and triplers, a klystron providing a multiplication factor of 11 in one tube, and a power amplier. If the oscillator operated at 5 mc the final output of the transmitter would be 2970 mc

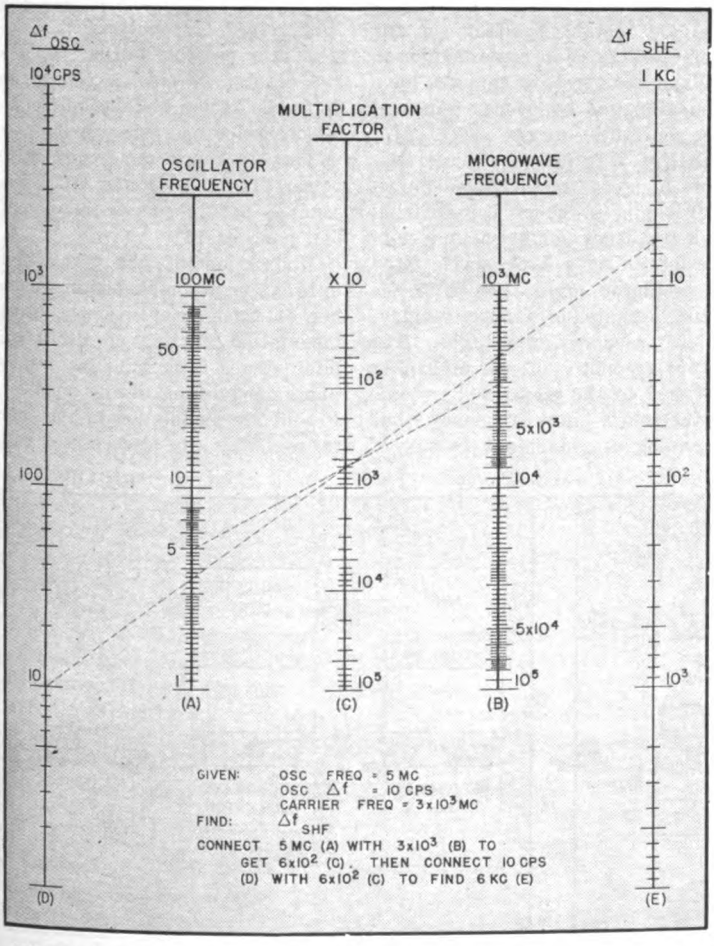

FIG. 5—Chart useful in determining the amount of carrier shift caused by a shift in the frequency of an oscillator, where the microwave transmitter employs a frequency multiplier chain. An example is given

Equipment operating in the microwave bands can have a frequency stability as good as that obtainable on the lower frequency bands, with 0.001 percent not too difficult. Crystal control is commonly used, with the oscillator operating at a frequency of several megacycles, followed by a series of frequency multiplier stages. The stability of the carrier is that of the crystal oscillator multiplied by the factor required to increase the crystal frequency up to the microwaves. The nomograph in Fig. 5 provides a convenient means of determining microwave frequency shifts caused by small frequency changes in the low frequency oscillator.

Commercial AT-cut crystals in temperature-controlled ovens have been used in many oscillators to furnish a stable driving source for the multiplier chain. Usually the multiplying stages are doublers and triplers, although quintupling has been used successfully. As the stages approach the ultra high frequencies the tank circuits change from coils and capacitors to resonant lines in various forms. These give way to resonant enclosures or

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cavities at the super-high frequencies. If the signal is of too low power at the carrier frequency it is frequently amplified to usable levels with tubes, such as klystrons, employing the velocity modulation principle.

Although crystal control has been considered the best means of obtaining a stable carrier at conventional frequencies it is having considerable competition from various automatic frequency control (afc) systems used for stabilizing microwave oscillators. Stabilities comparable to that obtained from a crystal-controlled multiplier chain can be had from a correctly designed afc unit.

At conventional frequencies it is possible, by comparing the phase of the amplitude modulated output from a resonant circuit with the original frequency modulating signal, to obtain a correction voltage which can be used to adjust the system so that the carrier and the resonant-circuit frequencies coincide. A similar afc scheme can be used on the microwaves, employing a resonant cavity as the tuned circuit. By making the resonator tunable, the microwave oscillator can be automatically stabilized on any frequency within this tunable band. This is advantageous because of the fact that in crystal control systems the complete multiplier chain must be retuned if the carrier frequency shift is large compared to the bandwidth of the resonant circuits.

Other low-frequency afc techniques can also be applied to microwave apparatus. For example, the variable-magnitude reversible-polarity voltage from a receiver discriminator can be used to keep a microwave local oscillator in track with an incoming signal. This is similar to the system used in some broadcast receivers.

Transmitter Design Considerations

To illustrate what is possible in modern microwave transmitter designs it is worthwhile to consider a general example, and to show how crystal control and afc compare for the job. Suppose it is desired to build a single channel f-m transmitter capable of a frequency deviation of ± 75 kilocycles and a frequency stability of 0.001 percent, with a carrier power of a few watts in the 10-cm microwave region. In this discussion it will be assumed that any detuning effects in the resonator and line circuits due to ambient temperature changes have been corrected by proper temperature-controlling means.

In Fig. 6 is shown a block diagram of a crystal controlled multiplier chain, in which conventional high-frequency doublers and triplers driven by a 5-megacycle crystal oscillator supply power to the input resonator of a velocity-modulation frequency multiplier. The output resonator of the multiplier is tuned to the eleventh harmonic of the tube's input frequency, thus providing a convenient means of obtaining an eleven-to-one frequency multiplication in one tube. Other multiplying values could be obtained by changing the ratio of the resonant frequencies of the output to input cavities. A two-stage cascade power-amplifier klystron is then used to raise the level from a few milliwatts to several watts output. The amplifier has a power gain of about 1000.

To maintain a microwave carrier frequency stability of ± 0.001 percent the crystal oscillator frequency must not deviate more than ± 0.001 percent. To accomplish this the plate and screen voltages on the crystal oscillator are kept low and are maintained at a constant potential by means of a gas tube or an electronic regulator. With modern crystal ovens capable of holding their temperature constant to better than one degree Centigrade throughout the ambient temperature ranges encountered in practice, it is possible to limit an AT-cut crystal to only a few cycles drift. To keep a well designed crystal oscillator operating in the five-megacycle range on frequency to better than ± 50 cycles (0.001 percent) is not difficult as this is only one part in 10^5.

Modulation of the transmitter unit can be accomplished in a number of ways. For example, phase modulation of any of the multiplier stages is possible, as well as phase modulation of the amplifier. Frequency modulation of the crystal oscillator can also be used with

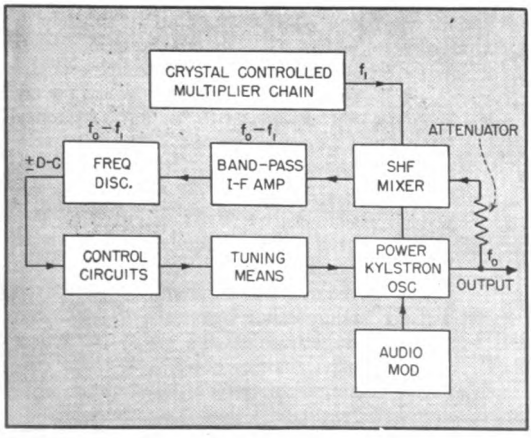

FIG. 7—Transmitter employing automatic frequency control of a modulated oscillator to achieve stability. Here a low-power crystal-controlled multiplier chain is used as the standard

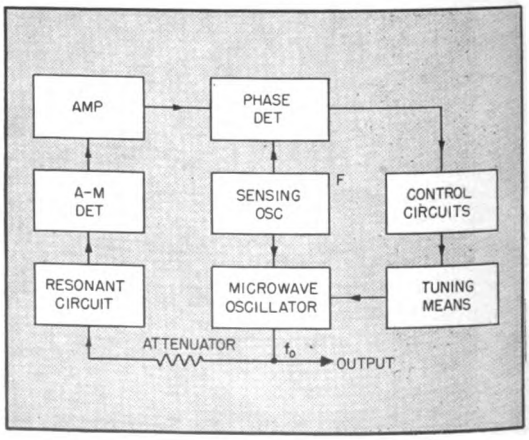

FIG. 8—Modulated oscillator employing a temperature-compensated cavity resonator as a resonant-circuit standard for the automatic frequency control system

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success, even though the frequency deviations available from such an arrangement are quite small. The high multiplication factor between the crystal and carrier frequencies (594 for the above example) increases any oscillator deviations into carrier swings of considerable amounts. This is also the reason that good carrier stability is required in systems using relatively narrow band transmission.

AFC System

With automatic frequency control it is possible to stabilize a powerful velocity modulation type of oscillator tube operating in the desired microwave band or to control a low power microwave oscillator and then follow it with a cascade power amplifier. In either case it is necessary to have a source of frequency reference to use as the standard of comparison. This frequency standard can be either a compact crystal-controlled source such as the multiplier chain described earlier or a temperature-stabilized resonant cavity tuned to the transmitter frequency. The basic principle involved in applying automatic frequency control is the same regardless of the type of standard used. The frequency of the transmitter is compared to the known standard frequency. Any random carrier shift is detected in the comparison circuit, and the resulting signal is used to apply a tuning correction to bring the carrier back into step with the standard. The loop gain and the bandwidth of the feedback control circuit determine how closely the carrier will be held to the standard.

Figure 7 shows a block diagram of an automatic frequency control system using a low-power crystal-controlled frequency multiplier chain as the standard. The purpose of such an arrangement is to provide a stable high-power transmitter in the absence of a suitable microwave power amplifier to follow the multiplier chain. In the diagram it will be noticed that the frequency of the standard is different from the transmitter frequency by an amount required to produce a convenient intermediate frequency signal, which is generated in a suitable mixer. The i-f amplifier has sufficient gain to operate a frequency discriminator of conventional design, similar to those used in current f-m practice. The bandwidth of the amplifier should be sufficient to allow the system to lock-in without too much searching. If the bandwidth is too wide, tightness of frequency control will be sacrificed, and if it is too narrow, fast deviations will not be corrected, so a compromise solution is needed which depends upon the requirements imposed upon the transmitter itself. Schemes can be devised to provide a wide pull-in range and a tight hold-in range simultaneously. The signal from the discriminator is a d-c potential whose magnitude and polarity depend upon how far the transmitter frequency has drifted, and in which direction. This variable-magnitude reversible-polarity voltage can then be used to control either a two-phase tuning motor, or the electrical power in any other electromechanical device, or can be applied through suitable amplifiers directly to an electrode in the transmitting tube which is frequency sensitive to voltage. The various tuning means can be used alone or in combination with one another.

Another method of obtaining automatic frequency control is to use a temperature-compensated cavity resonator rather than a crystal as the standard resonant circuit for frequency reference, as illustrated in the block diagram of Fig. 8. This circuit is used to obtain correction signals in a manner similar to the low frequency technique mentioned earlier. The standard resonant circuit is tuned to the frequency of the microwave oscillator, and the resonance curve of the cavity together with an amplitude detector as its load are used to convert transmitter frequency shifts into corresponding amplitude changes.

For purposes of illustration, assume that the transmitting microwave oscillator is frequency modulated with frequency F. If the transmitter is exactly in tune with the resonant cavity, the frequency modulation will be converted into amplitude modulation of frequency $2F$, as shown in Fig. 9A. This is true since a half-cycle carrier swing allows the signal amplitude to increase and then decrease again to its original value, hence one a-m cycle is produced during each half cycle of f-m caused by the modulating frequency F. Should the transmitter be slightly out of tune with the resonant circuit, the amplitude modulation output will be predominantly of fundamental frequency F, and in phase with the modulating signal F when the carrier has shifted to one side as shown in Fig. 9B. The amplitude modulation output will be 180 degrees out of phase, Fig. 9C, when the carrier

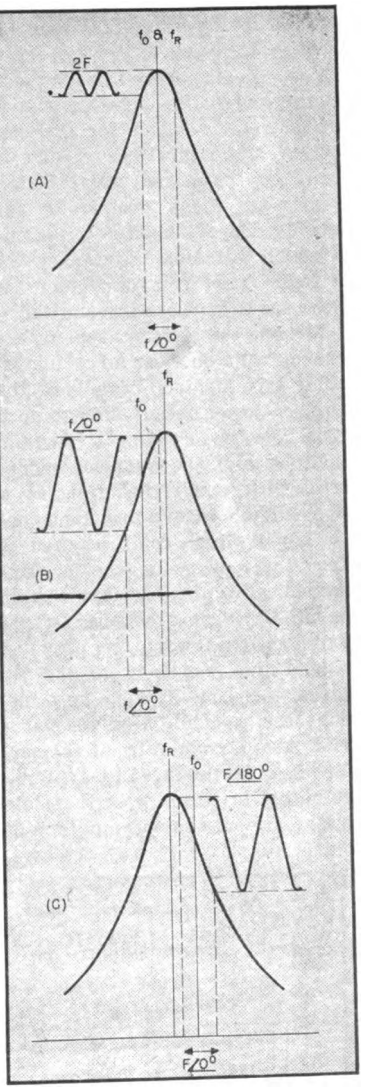

FIG. 9—Curves illustrating the operating principle of the afc system diagrammed in Fig. 8 and discussed in the text. (A) Microwave oscillator in tune with the resonant circuit used as a frequency standard. (B) with the carrier shifted to one side and (C) with the carrier shifted to the other side

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shift is in the other direction. It is this 180-degree phase shift which, when compared to the phase of the original modulating signal, provides the sensing for the control circuit in this type of afc system. The phase detector produces a voltage whose magnitude and polarity depends upon how far and in which direction the carrier has drifted. This control voltage is then used to tune the transmitter.

Perhaps the simplest type of afc transmitter would use an oscillator-buffer type klystron capable of the required power output and equipped with electro-mechanical tuning. The tube might be frequency modulated with small deviation at a super-audible rate to provide a control signal which could be used to alter the power in the electro-mechanical tuning device to keep the oscillator on frequency. Sufficient loop gain would be provided to hold the frequency to the required tolerance, taking into account the possibility of resonator drift. Audio modulation of the carrier might be produced by applying the signal in series with the plate voltage, the maximum amplitude of this audio voltage being adjusted to allow a ± 75 kilocycle carrier swing, the same as in the crystal controlled example. The afc system should be made insensitive to frequency shifts occurring in the audio passband.

Receiver Design Considerations

The basic receiver circuit used at microwave frequencies is still the superheterodyne. The i-f amplifier is usually operated at a considerably higher frequency than in similar lower frequency receivers. New and improved tubes have been developed to keep pace with the steady increase in frequency of the i-f amplifiers. Unfortunately, the local oscillator for microwave communication receivers presents a rather special problem. It is important that it be stable in frequency and yet compact, so that the receiver is not excessively large. Several local oscillator arrangements are possible, using crystal control or afc techniques.

The present difficulty with crystal control for this particular application is the amount of space and power required for the multiplier chain, which may consist of several tubes and their tuned circuits, and a klystron multiplier. Another problem with this type of local oscillator is the lack of a simple channeling means, unless the i-f amplifier is made tunable to accomplish the channeling. The tunable i-f amplifier arrangement is a perfectly practical method of obtaining the channeling feature.

Figure 10A shows a block diagram of a crystal controlled receiver, using a tunable i-f amplifier. Notice that in this case the whole i-f amplifier is gang tuned, including the discriminator, a condition which makes it difficult to maintain a constant bandwidth over the complete tuning range of the amplifier. To avoid this difficulty, the double superheterodyne or triple detection method can be used, as shown in Fig. 10B. The first local signal is fixed in frequency, and may be generated by a crystal-controlled unit. The second local oscillator has automatic frequency control similar to that used in some broadcast receivers. Only the second mixer and the second local oscillator need to be tuned (unless a first i-f stage, shown dotted, is used before the second mixer), and the bandwidth problem does not arise since the second i-f amplifier operates at a fixed frequency. A system of this type is the same as using a crystal-controlled microwave converter feeding directly into a standard f-m superheterodyne receiver with afc applied to its local oscillator.

Another method of obtaining a satisfactory microwave local oscillator is to use a compact microwave generator of the reflex type, and to apply automatic control to this local oscillator from the discriminator of the receiver, as shown in Fig. 11, in much the same way as afc is used in standard broadcast receivers.

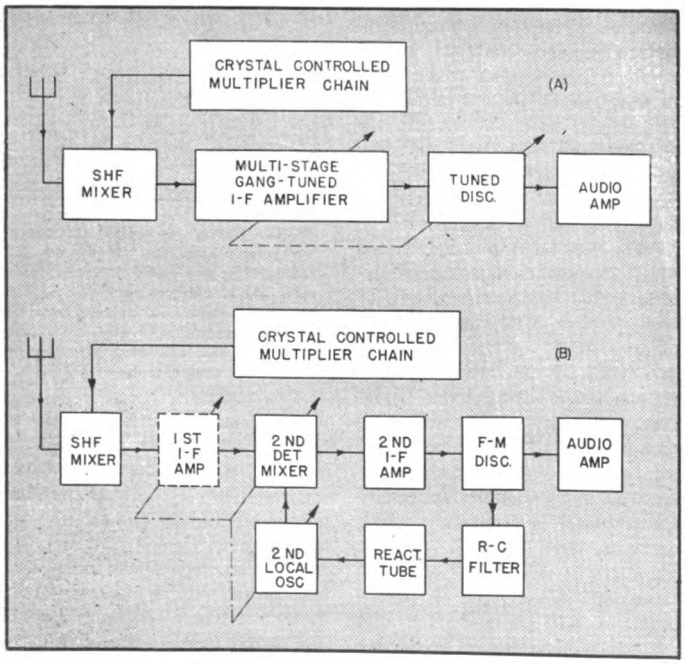

FIG. 10—Two methods of tuning a crystal-controlled superheterodyne receiver. (A) Tuning the i-f amplifier and the discriminator circuit. (B) Double superheterodyne with afc. If the first i-f amplifier stage, shown within dashed lines, is omitted only the second detector-mixer and the second local oscillator need be tuned

Experimental Systems

One early microwave experimental system was set up over a combination land and water path, slightly beyond line-of-sight range. The equipment used free-running klystron oscillators as the transmitters. Frequency modulation was produced by applying an audio signal in series with the plate voltage

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of the oscillators. Only a small amount of modulation voltage was required, since the 10-cm carrier deviation used in the system was purposely limited to ±75 kilocycles.

One receiver consisted of a standard f-m broadcast unit, fed by a microwave converter which used a tunable reflex klystron as the local oscillator and a silicon crystal as the mixer. Automatic frequency control was employed to keep the receiver in tune with the free-running transmitter. The voltages obtained from the discriminator were passed through an *R-C* network of long time constant to filter out the audio signals present, and were then used to control a tuning motor. The other receiver in this two-way communications system used a somewhat different scheme for obtaining automatic frequency control. The voltage from the discriminator was brought out through a low-pass filter, but was applied to an electro-mechanical tuning unit connected to the local oscillator. The discriminator control voltage was also used to provide electrical tuning for correcting transient deviations which the electro-mechanical device could not follow.

The transmission path covered a distance of 21 miles. With a power of several watts and parabolic antennas at each end, each with an effective gain of about 450, the signal output from the mixer of each receiver was well above the 50-microvolt level required by the f-m units. The system maintained normal communications when lower frequency channels failed due to interference conditions.

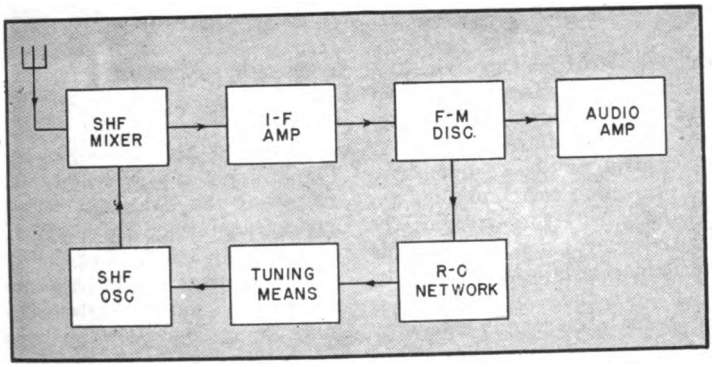

FIG. 11—Block diagram of a microwave receiver employing automatic frequency control alone to achieve the desired stability

A later system was installed over a five-mile link, using crystal control in both the transmitters and the receivers. The frequency multiplier chain used to increase the crystal frequency to the microwave region was identical in circuit design for the transmitters and receivers. The basic circuit of the frequency modulated crystal oscillator used is shown in Fig. 12. A modified Pierce parallel oscillator was used, with capacitive reactance in series with one grid and the crystal, and inductive reactance in series with the other grid and the crystal. If the tube with the capacitive reactance in its grid circuit oscillated alone, it would operate at a frequency slightly higher than that of the crystal, due to the leading phase shift at its grid. The other tube, oscillating alone, would operate at a frequency slightly lower than that of the crystal, due to lagging phase shift in its grid circuit. The two tubes are thus arranged to oscillate an equal amount above and below the crystal frequency, and their common tank circuit is tuned to the crystal frequency. It will be seen that it is possible to swing the frequency of the oscillator unit about the crystal frequency by several hundred cycles per second when audio modulation is applied in push-pull to the screen grids of the two tubes.

The frequency swing that such an oscillator is capable of producing is somewhat less than the initial oscillating frequency separation of the two tubes. The factor which determines the maximum separation possible with stable operation is the *Q* of the crystal

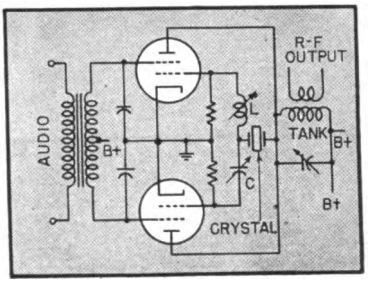

FIG. 12—Basic method of screen-grid modulating a crystal-controlled oscillator. Useful as a low-power f-m signal source, the circuit is a modified Pierce design with the two tubes in parallel

feedback loop. No amplitude modulation is present in the unit, because as one tube begins to take over frequency control it also increases its power output, while the other tube, in losing control, reduces its output. This keeps the net power output of the oscillator constant over the entire frequency swing.

Other crystal-controlled microwave systems have been built, using phase modulation in one of the frequency multiplier stages, with good results. Even though the phase swing is rather limited in such an arrangement, the large multiplication factor again brings it up to values which are quite usable on the microwaves.

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BRIDGE NULL-

Delayed automatic-gain-control permits utilization of high sensitivity in this a-c bridge null-indicator with visual indication of phase and amplitude relations

By E. W. HEROLD
RCA Laboratories
Princeton, New Jersey

AN essential element of an a-c bridge, such as those used for vacuum-tube measurements, is a detector or null-indicator.[1] The day in which a pair of earphones sufficed has long since passed. The present paper describes a tuned null-indicator, for a 1000-cycle bridge, which possesses many advantages, including delayed automatic-gain-control and both cathode-ray and meter-indication of output.

Requirements

Experience has shown that the chief requirements of a good null indicator are high-sensitivity near balance, adequate discrimination against harmonics, ability to distinguish phase in the off-balance position, a visual output indicator to minimize operator fatigue, and overload protection when the bridge is far off balance. The high sensitivity is easily met by a two-stage pentode amplifier. At the same time, a delayed automatic-gain-control may be used as overload protection for conditions far off balance without destroying the sensitivity at balance. Harmonic discrimination is accomplished by using tuned choke or transformer coupling while phase is shown by a cathode-ray type of indicator.[2] In addition, a sensitive output meter is a useful supplementary unit.

The Circuit

A circuit diagram is shown in Fig. 1. Input is to be connected directly to the bridge through a tuned transformer which is a part of the bridge itself, as in the General Radio type 561-D. A manual gain control permits reduction of large inputs to below the value which operates the automatic-gain-control circuit. The two-stage

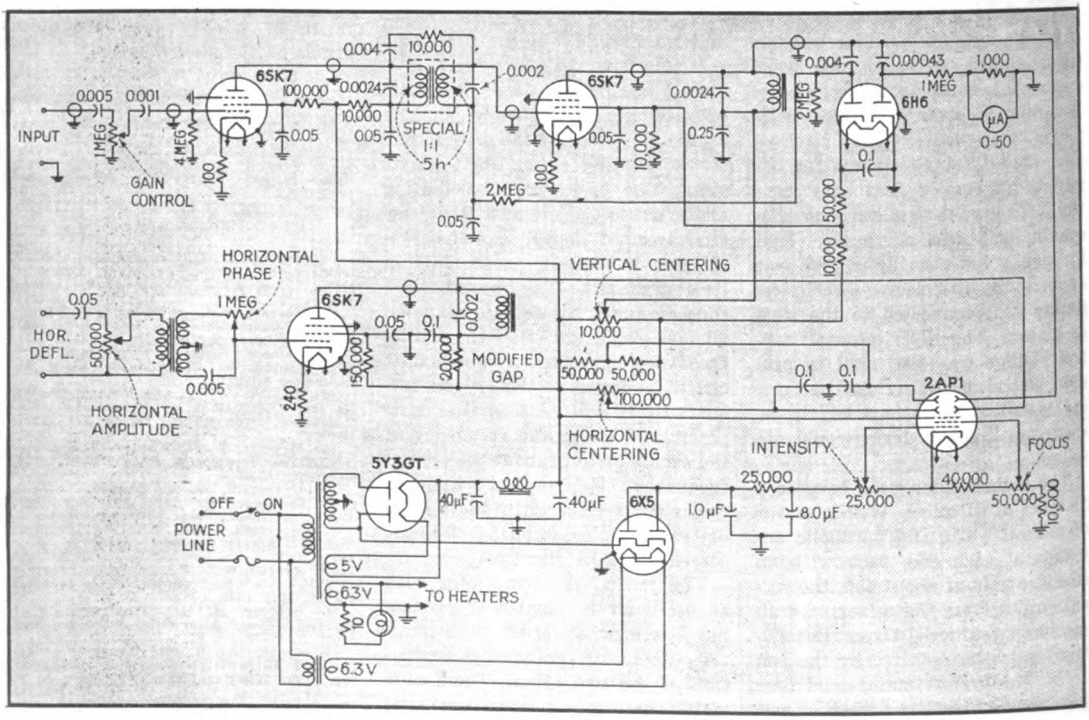

FIG. 1—Complete schematic of null-indicator. This circuit offers high sensitivity, discrimination against harmonics, ability to distinguish phase, visual output indication and overload protection

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INDICATOR

All controls are plainly marked and are easily accessible in this rack version of the bridge null-indicator

6SK7 amplifier has a special interstage transformer, designed by Mr. Otto Schade of RCA Victor and made by the American Transformer Company, mounted in a mu-metal shield can. For highest Q, about 13 at 1000 cycles, the interstage transformer tuning capacitance is split between primary and secondary as shown. A first-stage gain of over 500 is obtained. The *R-C* series combination, joining the high side of primary and secondary, eliminates high-frequency resonance (around 7000 cycles) due to the second resonance peak of a double-tuned circuit. The transformer must be correctly poled for this connection to be effective.

The second 6SK7 with a tuned-choke plate load, which has a 1000-cycle Q of about 5, is coupled, directly to one vertical deflection plate of a 2AP1 cathode-ray tube, which serves as an output amplitude and phase indicator. A second indication is obtained by reading the rectified current of one of the 6H6 diodes on the output meter. The other 6H6 diode, used for automatic gain control, has a positive delay bias of about 100 volts applied to its cathode. The automatic-gain-control voltage is applied to the grid of the second 6SK7 and gives adequate limiting action by a combination of bias variation and plate-circuit overload as shown in Fig. 2. The meter shunt is adjusted to give full-scale indication with maximum input.

Horizontal deflection voltage for the cathode-ray tube is obtained through a separate input from the bridge source, and is amplified by a single 6SK7 tube operated with a tuned-choke plate-load (a 6SJ7 is now being used here). The power supply, centering circuits, etc., are straightforward. The cathode-ray tube is operated with its cathode 300 volts below ground through the 6X5 rectifier, thus providing a second anode voltage of 600 volts from an ordinary 300-volt power supply transformer.

Performance

An input of 10 microvolts is sufficient to give an observable indication on either the meter or the cathode-ray vertical deflection. Figure 2 shows the input vs. output curve of the instrument at full gain. As the input is increased, the indication increases linearly up to about half scale on the meter, at which point the automatic gain control begins to operate. Thus, full sensitivity is realized over about half the meter range and yet the meter can never go off scale.

Phase indication on the cathode-ray tube is made by the method devised by Lamson.[2] With this method, a resistive unbalance of the bridge is caused to give a tilted line on the cathode-ray tube by adjustment of the horizontal phase control. An unbalance in the opposite direction is shown by a reversal of slope of the line, and perfect balance by a horizontal line. Reactive unbalance of the bridge causes the cathode-ray pattern to become an ellipse. The output indicating meter may be used as a simple null instrument and also as a quantitative indicator of the relative amount of input voltage to the instrument.

The selectivity of the null indicator, without an input transformer, is shown in Fig. 3. It is seen that second-harmonic discrimination is about 35 db and higher harmonics are attenuated even more. When the selectivity of a tuned input transformer (the bridge output transformer) is added to this, the harmonic reduction meets the most severe requirements.

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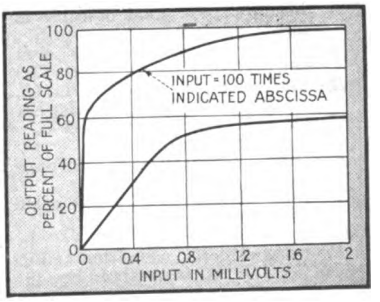

FIG. 2—Sensitivity curve, showing effect of delayed automatic-gain-control at high input levels

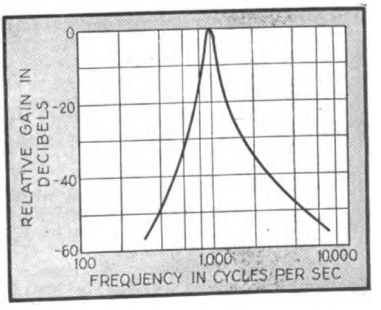

FIG. 3—A high degree of selectivity is obtained by the coupling methods used in the null-indicator

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Coaxial Cable Tests

Production testing methods suitable for coaxial cable depend upon ease of testing and reducing data to cable parameters. Open and shorted cable lengths are substituted into either bridge or resonant circuits using variable air capacitors for balance.

By PERRY H. WARE

Laboratory Engineer
Simplex Wire and Cable Co.
Cambridge, Massachusetts

IN TESTING radio-frequency coaxial cables we must decide what cable properties it is desirable to know. Parameters of prime interest to the user of cable are the working parameters, that is: characteristic impedance and propagation function. With a knowledge of these parameters the designer of radio-frequency equipment can calculate the performance of the installed cable. The cable design engineer is, of course, vitally interested in these same factors, but he also must know the basic parameters of the cable, that is: resistance, inductance, conductance, and capacitance.

We are therefore interested in measuring all the parameters of the cable, both basic and working. The method will be chosen principally for ease and accuracy of measurement and computation.

Test Frequency

It has been found expedient in laboratory cable testing to standardize the test frequencies, for several reasons.

Many specifications are written giving limits for cable parameters at specified frequencies. Using a few predetermined frequencies it is possible, with a minimum of testing to make comparisons with other cables and from previous experience to estimate probable behavior at other frequencies. Corrections depending on frequency, which must necessarily be made at high frequencies, can be systematized by graphs and tables thereby cutting the time of computation and reducing the probability of computation error. In a test where actual manipulation of instruments may take ten minutes or less and computations may occupy three-quarters of an hour, the time factor becomes important.

Measurements will, therefore, be made at fixed frequencies. This consideration almost entirely eliminates methods of test which require specific electrical lengths; in fact it is impractical to vary the length of a cable until an exact resonant length is obtained. Further, at frequencies below one megacycle, a quarter wavelength of cable becomes too long physically for convenient laboratory testing.

The principal method left is measurement of impedance of the cable with the far end successively short-circuited and open-circuited. Characteristic impedance and propagation constant may be determined from these measurements by the relationships

$$Z_o = \sqrt{Z_{sc} Z_{oc}} \qquad (1)$$

$$\gamma = (\tanh^{-1}\sqrt{Z_{sc}/Z_{oc}})/l = \alpha + j\beta \qquad (2)$$

The symbols used in equations are defined in Table I.

Regardless of the instrument or circuit used for measurement, open-

α	—attenuation of cable in nepers per unit length; αl: Eq. (19)
β	—phase shift of cable in radians per unit length; βl: Eq. (20), (25)
B	—input susceptance of cable; B_{oc}: Eq. (4)
C	—capacitance at critical condition with unknown in circuit, measured; C', without unknown in circuit, measured; C_{oc}, input of cable: Eq. (3); C_m, mica capacitor, measured: Fig. 1(C); C_s, mica capacitor and cable in series, measured: Fig. 1(C); C_t, total of cable in farads, measured
γ	—propagation constant per unit length: Eq. (2), (18), (18a), (21)
D	—dissipation factor ($D = R\,\omega\,C$), measured; D_{oc} input of cable: Eq. (7), (15); D_m, see C_m; D_s, see C_s
δ	—phase angle of impedance
E	—potential, measured; E_R, at resonance
f	—resonant frequency of test cable length, measured
G	—conductance, measured
θ	—phase angle; θ_{oc}, admittance: Eq. (5), (7); θ_{sc}, impedance: Eq. (9)
I	—current, measured; I_R, at resonance
l	—length of cable sample
n	—number of quarter wavelengths of cable sample
oc	—subscript indicating cable output is open circuit
R	—resistance, measured, see C: R', see C'; R_m, see C_m; R_s, see C_s; R_{oc}: Eq. (16)
ϕ	—phase angle of admittance
sc	—subscript indicating cable output is short circuit
X_{sc}	—reactance at cable input with cable output a short circuit: Eq. (8), (11)
Y_{oc}	—admittance at cable input with cable output an open circuit: Eq. (6)
ψ	—phase angle of tanh $\gamma\,l$
Z	—complex impedance; Z_o, characteristic: Eq. (1), (17), (17a) (30); Z_{oc}, see Y_{oc}; Z_{sc}, see X_{sc}: Eq. (10)

TABLE 1—Symbols for coaxial cable measurements discussed in the text

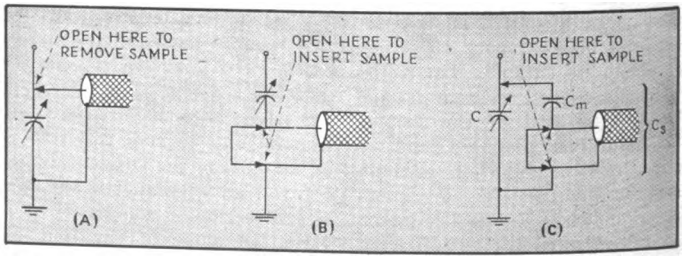

FIG. 1—Coaxial cable can be connected into measuring circuit by (A) parallel substitution, (B) series substitution, or (C) series-parallel substitution

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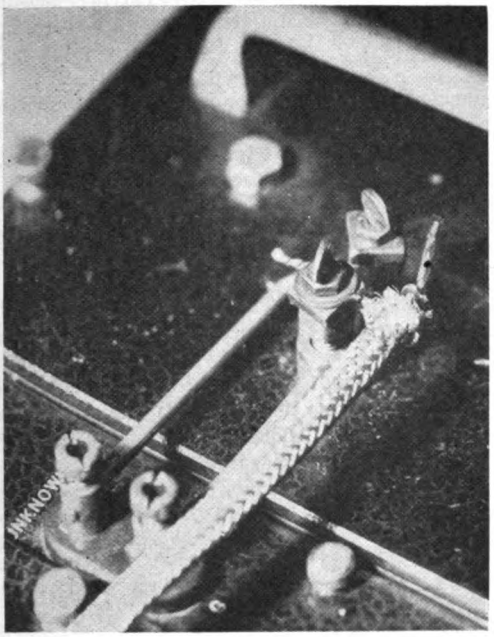
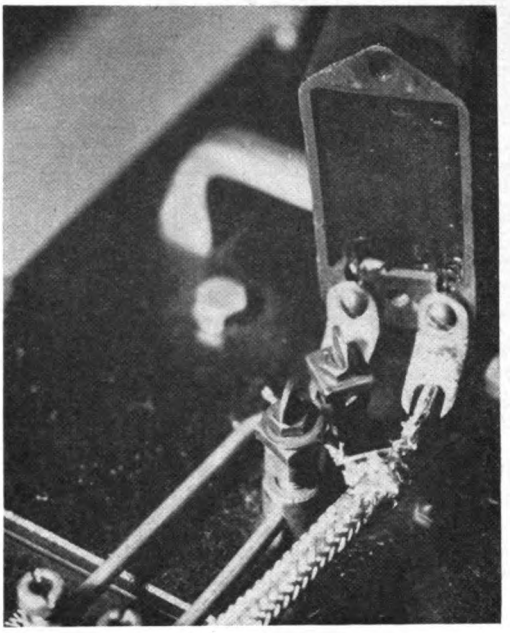


Coaxial cable in position for parallel substitution measurements has its outer conductor connected to the variable air capacitor. The parallel combination of cable and capacitor is connected across the unknown terminals of a bridge



For series-parallel substitution a short wire is soldered between the outer coaxial braid and the inner conductor thereby shorting the cable. Cutting wire places cable and mica capacitor in series across the capacitor

circuit and short-circuit impedances may be determined with the least probability of unaccounted-for errors by some form of substitution measurement.

Substitution Measurements

Circuit components, which at audio frequencies may be considered as pure elements such as resistances and inductances, will in general show at radio frequencies distributed capacitance, inductance, and resistance, which alter their behavior. At high frequencies the stray component becomes appreciable, and introduces into any circuit containing it an impedance which may be neither readily calculated nor measured.

In general, the most satisfactory standards at radio frequency are fixed resistors and variable capacitors. Fortunately the residual resistance and inductance of an air capacitor can readily be measured, and from these measurements its behavior may be accurately predicted.

A substitution method will reduce to a minimum the necessary corrections to be made in either bridge or resonance methods. If all impedance is defined in terms of fixed resistance and variable capacitance, with reasonable precautions such as correct shielding and correction for residual parameters, impedance can be measured up to sixty megacycles.

Parallel Substitution

The parallel substitution method illustrated in Fig. 1(A) is commonly used for measurement of relatively high impedances such as short lengths of cable under open-circuit conditions. Results are most conveniently expressed as admittance (the reciprocal of impedance) or as capacitance, which is measured directly.

Bridge balance or resonance is established with a variable air capacitor alone in the circuit. The unknown is then connected in parallel with the air capacitor, and the latter is varied until either the bridge is rebalanced or the circuit is returned to resonance. The capacitance of an open-circuited sample is then given by

$$C_{oc} = (C' - C) \qquad (3)$$

and susceptance by

$$B_{oc} = \omega C_{oc} \qquad (4)$$

If, for example, the initial setting of the capacitor at a frequency of 100 kilocycles is 1000 $\mu\mu$f, and the second setting is 200 $\mu\mu$f, C_{oc} = 800 $\mu\mu$f, and $B_{oc} = 2\pi\ (10^5)\ (800)\ (10^{-12}) = (503)\ (10^{-6})$ mho. Assuming a capacitor having a range

TABLE II—Reactance limits of series or series-parallel substitution

Freq in Mc	C' in μf	Inductance Range	Capacitance Range in μf
0.01	0.10 — 0.25 — 25 μh		10.0 — 1000
	0.01 — 0.025 — 2.2 mh		0.1 — 10
	0.001 — 2.5 — 130 mh		0.001 — 0.1
0.10	0.01 — 0.25 — 22 μh		0.1 — 10
	0.001 — 0.025 — 1.3 mh		0.001 — 0.1
1.0	0.0009 — 0.32 — 2.5 μh		0.08 — 0.001
	0.0005 — 1.0 — 25 μh		0.025 — 0.001
	0.0001 — 25.0 — 220 μh		<0.001
10.0	0.0006 — 0.007 — 2.0 μh		0.0013— 0.037

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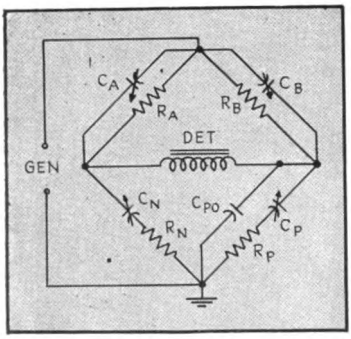

FIG. 2—For measurements from one kilocycle to five megacycles the Schering bridge is the most usable

of 100 to 1100 $\mu\mu$f, the range of values which may be measured with reasonable accuracy is given in Table II.

The conductive component of the unknown admittance is the difference between the conductance of the parallel combination and that of the air capacitor alone, as determined by the particular measuring circuit used. A bridge will often be designed to yield results in the form of dissipation factor (tangent of the defect or loss angle); if so the complex admittance may easily be determined both in phase angle and magnitude from the relationships

$$\cot \theta_{oc} = D_{oc} \quad (5)$$

$$Y_{oc} = B_{oc}/\sin \theta_{oc} \quad (6)$$

If G_{oc} is measured directly, we can also apply the following

$$\cot \theta_{oc} = G_{oc}/B_{oc} = D_{oc} \quad (7)$$

In all these measurements, to reduce the determined cable parameters to unit length the results given above should be divided by the length of the measured cable.

Series Substitution

For measurement of low impedances such as short-circuited samples of short length, a series substitution method illustrated in Fig. 1(B) is used. The initial balance is made as before on a variable air capacitor or, particularly at frequencies below one megacycle, on a mica capacitor of suitable capacitance using a variable air capacitor in parallel as a means of measuring increments of capacitance.

The unknown impedance is inserted in series with the capacitor, often by removing a short-circuiting lead from its terminals, and initial conditions are re-established by resetting the air capacitor. The reactance of the short-circuited sample is given by

$$X_{sc} = (C - C')/\omega CC' \quad (8)$$

The resistive component of the unknown impedance is the difference between the resistance of the series combination and the effective series resistance of the capacitor alone, as determined by the particular measuring circuit used: $R_{sc} = R - R'$.

The complex impedance, in magnitude and phase, is computed from the expressions

$$\cot \theta_{sc} = R_{sc}/X_{sc} \quad (9)$$

$$Z_{sc} = X_{sc}/\sin \theta_{sc} \quad (10)$$

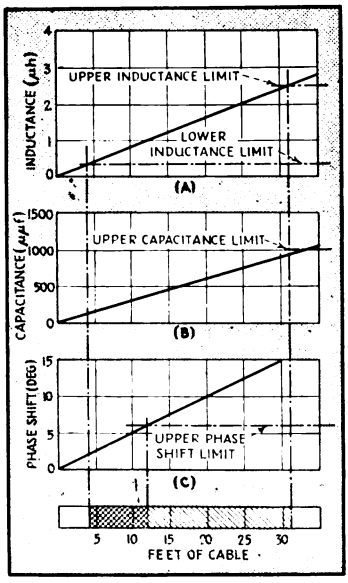

FIG. 3—To determine the sample length to be used in cable testing, a chart of this type is made

As an example, at 100 kilocycles C' is 0.01 μf, C is approximately 0.01 μf and the difference, measured with the air capacitor is 25 $\mu\mu$f. The reactance given by Eq. 8 is $X_{sc} = (25)\ (10^{-12})/2\pi\ (10)^5\ (0.01)\ (0.01)\ (10^{-12}) = 0.398$ ohm.

Series-Parallel Substitution

For measurement at frequencies of one megacycle and higher it is more convenient to use a modification of the series substitution method. In this case the substitution is made in series with a mica capacitor, with the initial and final impedances measured by a parallel-substitution method across a variable air capacitor; the method is called series-parallel substitution and connections are shown in Fig. 1(C). Reactance is given by

$$X_{sc} = (C_s - C_m)/\omega C_s C_m \quad (11)$$

If, for example, measurement by parallel substitution yields 1000 $\mu\mu$f for C_m and 1010 $\mu\mu$f for C_s at a frequency of one megacycle, then by Eq. (11) $X_{sc} = (10)\ (10^{-12})/2\pi\ (1000)\ (1010)\ (10^{-24}) = 1.578$ ohms.

Resistance Measurement

The resistive component of impedance is equal to the difference between the measured equivalent resistances of the series combination and of the mica capacitor alone. If the parallel-substitution measurement yielded dissipation factor for the two measurements (D_m and D_s respectively) the resistances are given to a close approximation by

$$R_m = D_m/\omega C_m \quad (12)$$

$$R_s = D_s/\omega C_s \quad (13)$$

and the resistance of the sample is $R_{sc} = R_s - R_m$. The complex impedance is computed as for the regular series substitution measurement. For either type of substitution, the useful range of measurement is shown in Table III.

Precautions should be taken in connecting and disconnecting the cable during measurements not to change stray lead impedances. Place equipment so that leads are moved but short distances, and stray capacitances are measured as part of the initial capacitance and do not appear as an error in the impedance of the sample.

Frequency Range

Until now only general methods of measurement have been discussed. The actual instrument or circuit used for these measurements is principally dependent upon the test frequency. Up to three megacycles, bridge measurements are entirely satisfactory. A Schering bridge designed for radio-frequency use has been used by the author with consistent results from one kilocycle to three megacycles; with proper design and correction for residual parameters, a bridge may be used as high as fifty megacycles.

Schering Bridge

In the Schering circuit of Fig. 2 the only variable elements are ca-

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pacitive. If a substitution method is used, the reactance balance is obtained with an air capacitor used in the unknown P arm of the bridge; phase balance is obtained with a variable air capacitor in the diametrically opposite A arm. For an equal-arm bridge (i.e., $R_A = R_B$) the total capacitance in the P-arm remains constant and the change in dissipation factor of the P-arm is given by

$$D_P - D_P' = (C_A - C_A')\,\omega R_A = \Delta D \quad (14)$$

If the bridge is originally balanced with the standard capacitor alone in the P-arm, using C_P and C_B to attain balance, introduction of the sample will necessitate a change in the standard capacitor and in C_A to rebalance the bridge. The change in dissipation factor of the entire P arm depends, not on an absolute value of C_A, but merely on an increment which can be accurately determined. If R_A is known, capacitor C_A may be calibrated directly in dissipation factor at a given frequency. This value is then proportional to frequency as shown by Eq. 14 and calibrated values may be multiplied by the ratio of test frequency to frequency of calibration to obtain values at other frequencies. Stray capacitance of the P arm are lumped into C_{PO}.

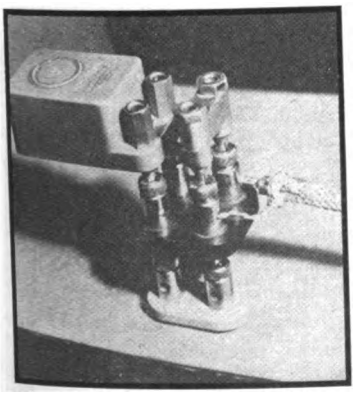
With the Schering circuit, dissipation factor of a capacitive sample measured by parallel substitution is given by

$$D_{ss} = [\Delta D(C_P' + C_{PO})/(C_P' - C_P)] + R_c\,\omega\,(C_P' + C_P) \quad (15)$$

For series substitution, the resistance is given by

$$R_{ss} = \Delta D(C_P' + C_{PO})/\omega\,C_P'^2 \quad (16)$$

The variable capacitor C_A can be calibrated in terms of resistance instead of ΔD by measuring an accurately known resistor as a standard. By this means, the absolute value of C_P' need not be accurately known, and correction for stray capacitance is automatically made. Correction should also be made for the residual inductance of leads in the P arm.



Fewest possible alterations should be made in changing connections. For series substitution, connection is arranged so that removing plug jumper at right inserts the mica capacitor in series with cable and at the same time removes the short on the cable

Resonance Method

It has been found expedient to use resonance methods at frequencies of five megacycles and higher. Ordinarily, the resistive or conductive component of the unknown impedance or admittance is determined from the width of the resonance curve, when current or voltage is plotted against capacitance setting of a variable air capacitor used as a standard.

The following means of interpreting resonance data, suggested by Sinclair, is less subject to the error which might occur in a single measurement. If the ordinate is made $\sqrt{(E_R/E)^2 - 1}$, and the abscissa capacitance, for parallel resonance, or if for series resonance $\sqrt{(I_R/I)^2 - 1}$ is plotted vs the elastance (reciprocal of capacitance), the real component of impedance may be determined from the slopes, and the reactive component from the intercepts on the axis. The limits of resistance which can be measured are determined by ability to distinguish between two very nearly equal slopes at one end, and by inability to obtain a wide enough portion of the resonance curve at the other.

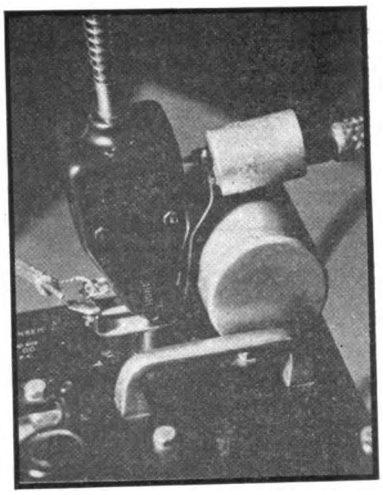
Calculation of Results

As mentioned earlier, characteristic impedance and propagation function may be computed from the complex values of short-circuit and open-circuit impedances. If both have been measured as impedance, the following equations apply

$$Z_0/\underline{\delta} = \sqrt{Z_{sc}\,Z_{oc}}/0.5\,(\theta_{sc} + \theta_{oc}) \quad (17)$$

$$\tanh \gamma l/\underline{\psi} = \sqrt{Z_{sc}/Z_{oc}}/0.5\,(\theta_{sc} - \theta_{oc}) \quad (18)$$

If, as is customary for short samples, the open-circuit measurement has been made in terms of admittance, the following modifications are used



Measurements by resonance method use resonant circuit in large lower shield. Vacuum-tube voltmeter, test cable (left), variable capacitor, and input circuit (right) are connected by rigid straps

$$Z_0/\underline{\delta} = \sqrt{Z_{sc}/Y_{oc}}/0.5\,(\theta_{sc} - \theta_{oc}) \quad (17a)$$

$$\tanh \gamma l/\underline{\psi} = \sqrt{Z_{sc}Y_{oc}}/0.5\,(\theta_{sc} + \theta_{oc}) \quad (18a)$$

The value of γl is determined from its hyperbolic tangent. For short lengths of sample, this is most readily accomplished by using

$$\tanh 2\alpha l = (2\,|\tanh \gamma l|\,\cos\psi)/(1 + |\tanh \gamma l|^2) \quad (19)$$

$$\tan 2\,\beta l = (2\,|\tanh \gamma l|\,\sin\psi)/(1 - |\tanh \gamma l|^2) \quad (20)$$

where $\tanh \gamma l$ is determined from Eq. 18 or Eq. 18a. Table IV gives approximations for characteristic impedance and phase shift which are valid under the specific conditions.

For lengths over ½ wavelength the above expressions still apply, but work may be sometimes simplified by using a hyperbolic tangent table. Another method of determining γl from the tanh is

$$\gamma l = 0.5 \log_e [(1 + \tanh \gamma l)/(1 - \tanh \gamma l)] \quad (21)$$

where, in general, $\log_e (r/\theta) = \log_e r + j\theta$. Having determined $\gamma l = \alpha l + j\beta l$, the propagation function per unit is easily obtained, since it varies directly with length. That is

$\alpha = \alpha l\ (1000/l)$ nepers/1000 ft.

$\beta = \beta l\ (1000/l)$ radians/1000 ft.

The primary constants may be found as follows

$$Z/\underline{\theta} = \gamma Z_0 = R + j\,\omega L \quad (22)$$

$$Y/\underline{\varphi} = \gamma/Z_0 = G + j\,\omega C \quad (23)$$

Resistance: $R = Z \cos \theta$ ohms/1000 ft

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TABLE III—Reactance limits of parallel substitution

Freq in Mc	Inductance Range	Capacitance Range in $\mu\mu$f
0.01	250 mh —25 h	10—1000
0.10	2.5 mh —250 mh	10—1000
1.0	25 μh —2.5 mh	10—1000
10.0	0.5 μh —25 μh	10— 500

TABLE IV—Approximate formulas for computing cable parameters

Condition	Formula
$\alpha l < 0.02$	$\alpha l = (\tanh \gamma l \cos \theta) / (1 + \tanh^2 \gamma l)$
$X_{sc}/R_{sc} > 5$ $B_{oc}/G_{oc} > 22$	$\alpha l = (R_{sc} / Z_0 + G_{oc} Z_0) / 2 (1 + Z_{sc} B_{oc})$ $\beta l = (Z_{sc} B_{oc})^{1/2} / (1 - Z_{sc} B_{oc})$ $Z_0 = (Z_{sc} / B_{oc})^{1/2}$

Inductance: $L = (Z \sin \theta)/\omega$ henrys/1000 ft

Conductance: $G = Y \cos \phi$ mhos/1000 ft

Capacitance: $C = Y \sin \phi/\omega$ farads/1000 ft

where γ and Z_0 are both considered as vector quantities, having magnitude and phase angle. If the length of sample is electrically short (i.e., less than 1/60 wavelength, or 6 degrees) $\tanh \gamma l$ does not differ by more than one percent from γl in either real or imaginary parts, and the primary constants may be computed from the measured values of short-circuit and open-circuit impedance as follows

$R = R_{sc}(1000/l)$ ohms/1000 ft

$L = (X_{sc}/\omega)$ $(1000/l)$ henrys/1000 ft

$G = G_{oc}$ $(1000/l)$ mhos/1000 ft

$C = C_{oc}$ $(1000/l)$ farads/1000 ft

Ultrahigh-Frequency Measurements

At ultrahigh frequencies neither bridge nor resonance methods may be used satisfactorily. The usual method of test consists of an attenuation measurement, generally of the insertion-loss type.

Insertion-loss methods depend upon measurements of power, voltage, or current at each end of a cable loosely coupled to an oscillator at one end and terminated in its characteristic impedance at the other. The attenuation constant can then be computed by whichever of the following relationships is applicable

Attenuation (db) = $10 \log_{10} (P_{in}/P_{out})$

Attenuation (db) = $20 \log_{10} (E_{in}/E_{out})$

Attenuation (db) = $20 \log_{10} (I_{in}/I_{out})$

Characteristic impedance can be measured by determining the frequency at which a length of cable becomes resonant (i.e., the frequency at which it is an odd quarter-wavelength electrically). From this frequency, and the capacitance of the whole length, which may be determined for nonpolar dielectrics at a lower frequency, the characteristic impedance is given by

$$Z_0 = 4nC_1 f \qquad (24)$$

Phase shift is determined from the same measurements by

$$\beta = 500\pi n/l \text{ radians/1000 ft} \qquad (25)$$

Relative velocity of propagation, expressed in percent of velocity in free space, is

$$\%V = 1.28 f l/\pi n \qquad (38)$$

Choice of Sample Length

If approximate values of the cable parameters are known in advance, it is possible to select a length of sample which will place the short-circuit and open-circuit impedance measurements in the middle of the testing range for the available equipment. In the first place, it is desirable to keep the length below approximately fifty feet from the standpoint of convenience. A typical example will show how sample length may be determined.

Cable parameters at one megacycle are

Resistance: 0.02 ohms per ft

Inductance: 0.80 microhenrys per ft

Conductance: 0.60 micromhos per ft

Capacitance: 30. micromicrofarads per ft

Phase shift: 0.5 degrees per ft

Figure 3 shows inductance, capacitance and phase shift as a function of sample length. Limiting values for inductance range using 900 $\mu\mu$f in a series or series-parallel substitution are shown in Fig. 3(A). The limits for capacitance range in a parallel substitution measurement across a capacitor having a range of 1000 $\mu\mu$f are shown in Fig. 3(B). The maximum limit for short-line calculations is shown in Fig. 3(C).

TABLE V—Optimum length of cable sample

Freq in Mc	Length in Ft
0.01	25—30
0.10	15—30
1.0	8—25
100.0	(100±25)

It may be seen that for ease in computation a 10-foot length of sample is satisfactory. If a longer sample, possibly more representative of the cable as a whole, is desired, and if time for calculation is not a deciding factor, a 20-ft to 30-ft length of sample may be used, and parameters computed from the long-line equations. Similar plots may be drawn for other frequencies and types of measurement.

For direct attenuation measurements it becomes necessary, in spite of considerations of convenience, to use a longer length. Too short a length would not yield inputs and outputs sufficiently different from each other to give precise computed values of attenuation. Table V shows test lengths which have been found convenient over the frequency range.

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Industrial Test Equipment Design

Circuit analyzers suitable for bench work frequently fail when subjected to necessarily rough treatment in the field and in shops handling heavy work. This article tells why they fail, and suggests design improvements

By TED POWELL
New York, N. Y.

THIS PAPER is based upon notes made during the training and supervision of a crew of repair-force men in a large east coast shipyard. It is slanted directly at postwar manufacturers of test equipment and is intended to bring out the fact that most circuit analyzers designed for shop work are inadequate for field duty since the conditions encountered are entirely different, especially where heavy construction work is in progress.

The shortcomings of the ordinary commercial analyzer can be summed up in a few words—inadequate provision for mechanical and electrical damage-protection, inadequate shock-proofing, and insufficient water and dust-proofing. The large damaged test equipment backlog in industrial plants doing essential war work is eloquent testimony to this fact.

Mechanical Damage-Proofing

Out in the field, tools may be dropped upon the analyzer, or it may be struck against ladder rungs, scaffolding, switchboards, etc. This common trouble points out the need for white-metal, brass or aluminum alloy knobs, or at very least more rugged plastic knobs. Welding and burner-torch sparks burn most plastic knobs.

Analyzer panels should be made of heavier-gage metal. If such equipment is leaned against accidently, or a fairly heavy weight is rested on it, the ordinary light-weight panel warps or collapses entirely. Furthermore, selector switches inside the analyzer case may be cocked and their wiring may strain against them. This often warps thin pancake switch sections enough to cause the contacts to open up.

The panel instrument or meter glass window is probably the biggest headache for field service technicians. If the palm of the hand is accidently pressed against the meter, or if the meter is struck against an obstruction, or if something is dropped on the analyzer, a collapsed or smashed glass is the usual result. If, instead of fitting the meter window in an inside recess, it could be set in an outside recess, it would at least not cave in on the dial and indicator or pointer at the slightest pretext. The meter could be further protected by a plate of Plexiglass or Lucite or some other non-brittle plastic.

Meter cases are too fragile as a rule. If an analyzer is accidentally dropped a few inches the weight of the meter parts often tears the meter case apart. A heavier case and base, and more anchoring screws between them, would greatly reduce trouble.

Flush-mounted meters are advisable, since protruding meter cases are struck against obstructions while the analyzer is carried about on a construction job. A protective cover cannot be perpetually opened and closed without wasting too much time on rush jobs.

Resistor assemblies should not be secured to small sub-assembly panels which, in turn, are secured to meter terminals. If the analyzer is accidentally dropped, the weight of the resistors in conjunction with the weight of the meter parts frequently tears the plastic meter case open or tears the case anchoring screws out of the meter base.

Industrial analyzer potentiome-

TYPICAL TROUBLES

- Control knobs break or burn
- Panels bend or collapse
- Meter glass moves or shatters
- Meter pointers stick
- Meter pointers bend
- Meter hair-springs buckle
- Meter cases smash
- Test-lead insulation wears
- Jacks and binding-posts weaken
- Switch contacts corrode
- Sub-assemblies shift
- Wiring tears loose
- Insulation resistance declines
- Ohmmeters burn out

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ters should be at least 1-watt units. They must be considered from the mechanical as well as the electrical angle for reasonable wear.

Jacks and binding posts should be more massive. The usual lightweight posts quickly wear out or develop loose contacts, and their insulation often breaks apart and falls through the panel. They should preferably be of a flush-panel design, to avoid breakage.

More rugged test leads are needed. Conductors often break at the plug-in jacks and at the plastic tubing end of the test prods. Edges, where the test-lead wire enters prods and jacks, should be chamfered off and cushioned with some sort of a flexible plastic sheath in order to prevent flex-point copper embrittlement and breakage.

Electrical Damage-Proofing

A serious and perpetual headache is the ohmmeter-burn-out-on-energized-circuit problem. One test crew is frequently unaware of what another is doing elsewhere on a job, and throws switches. The other crew, taking cold-circuit readings, sees its analyzer meter indicator or pointer do a rhumba, sees smoke curl up from behind the panel and says goodbye to the meter or multipliers or both.

Low-current fuse protection is rarely adequate protection because of the relatively high resistance and time-constant of fuses in the milliampere ranges. Some sort of midget relay protection is needed.

A switch or pushbutton-controlled neon indicator lamp would be useful in a copper-oxide meter type analyzer, to act as a voltage indicator. When both lamp electrodes glowed, the voltage under test would be a-c. When only one electrode glowed, the voltage supply would be d-c. This would reduce damage to sensitive copper-oxide rectifiers.

When an analyzer is accidentally connected across the wrong terminals excessive meter current may be drawn and the meter-movement-coil restraining hair-springs may buckle up or cone up. This spring-buckling action necessitates opening the meter case and flicking the buckled hairsprings back into shape again. Some sort of light-weight disks or cross-bars might be mounted on the coil-shaft close to the hair-springs to prevent them from buckling up.

A common design fault is the use of a single meter-indicator stop near the pivot end. When analyzer test prods are accidentally placed across the wrong terminals and the meter indicator slams across the dial it strikes the single stop, bends around it and either breaks off or is warped out of shape. If two stops were used, one near the pivot end as usual and one out near the indicator end, the indicator would not so often be damaged. Stops should be soft-spring cushioned to further reduce damage.

Shock-Proofing

Meter-pivot conical thrust-bearing points exert a pressure of from one-quarter to two tons per square inch upon their jewel bearings. If an analyzer is jarred sharply, pivot points are sometimes flattened and jewel bearings are gouged or fractured. Meter action becomes sticky and erratic and meter readings are worthless. For this reason, field-duty analyzers should be shock-proofed by floating them in sponge rubber or on springs. This would also reduce shock-demagnetization of meter permanent magnets.

Small jewel bearings might be spring-cushioned against collars, so that the springs would absorb shock. At the same time, the bearing clearance might be made adjustable.

Meter hair-springs can buckle up from severe vertical shock as well as from overload current. Not only will hair-springs buckle up under such a condition but they may also jam up in the fine turns of wire on the crossbar counterweights. Again, this points out the need for some sort of light-weight disks or crossbars next to the pivot hair-springs to prevent buckling action.

Analyzer wiring should be arranged and secured with an eye to shock and vibration conditions. Constant shock-flexing of wiring will result in crystallization at connection points, and breakage and opens. Similarly, if resistors are allowed to hang loosely, or have wiring or other components hanging from them, the internal connections may work loose.

Water and Dust-Proofing

Field service conditions often require the use of an analyzer under rain, snow, dust or fume conditions. Protective covers cannot be kept closed while tests are being conducted, especially on an emergency job. For this reason, industrial analyzers should be water and dust-proofed.

The meter panel can be recessed in a rubber-gasketed groove in the analyzer case. Test-lead jacks and binding posts, and the meter itself, can be set in rubber-washer mountings. The individual components can themselves be water-proofed.

Analyzer case covers could be rubber gasketed and could contain a water-tight plastic window, so that under severe conditions the cover could be closed down and readings taken through the window.

Wiring should employ one of the new synthetic-resin plastic-insulated wires now available. Such insulation is practically moisture, chemical, fungus and corrosion-proof. The 40 and 50-μa meters are highly sensitive and some older insulations, tightly laced, often develop too much leakage error, especially in the case of outdoor field-duty analyzers.

Soldered connections should be cleaned off with carbon tetrachloride during analyzer production, since most fluxes are hygroscopic. The consequent moisture absorption results in chemical and electrolytic corrosion at connections. It is advisable to paint over soldered joints with Glyptal, Dolph's Oil or asphalt paint such as Rubberoid. This is especially important where chemical fumes may later be present. Corrosion is especially troublesome at selector-switch connections.

Where severe moisture conditions are apt to be encountered, it is advisable to provide for an easily and externally replaceable cartridge of silica gel or some similar hygroscopic desiccant chemical in order to keep the analyzer interior dry.

Water-proofing the analyzer automatically keeps it dust-proof.

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This is of great advantage where testing must be carried out on, say, a steel construction job. Metallic dust and fragments work their way into the usual commercial analyzer and into the meter coil or magnetic air gap. This results in a sticky or jamming instrument, and the trouble cannot usually be corrected by blowing out or jarring.

Ordinary dust will also cause some trouble. It coats internal analyzer wiring and circuit components and insulation surfaces, moisture is absorbed by this dust film and leakage paths and corrosion are set up.

Design Suggestions

Batteries replaceable from the outside of an analyzer through water-tight covers would be a time-saving convenience and would stop unnecessary punishment of the analyzer wiring and components during the replacement routine.

Wider-scale meters are needed in analyzers. They save eye and nerve-strain, especially in poor-visibility field conditions.

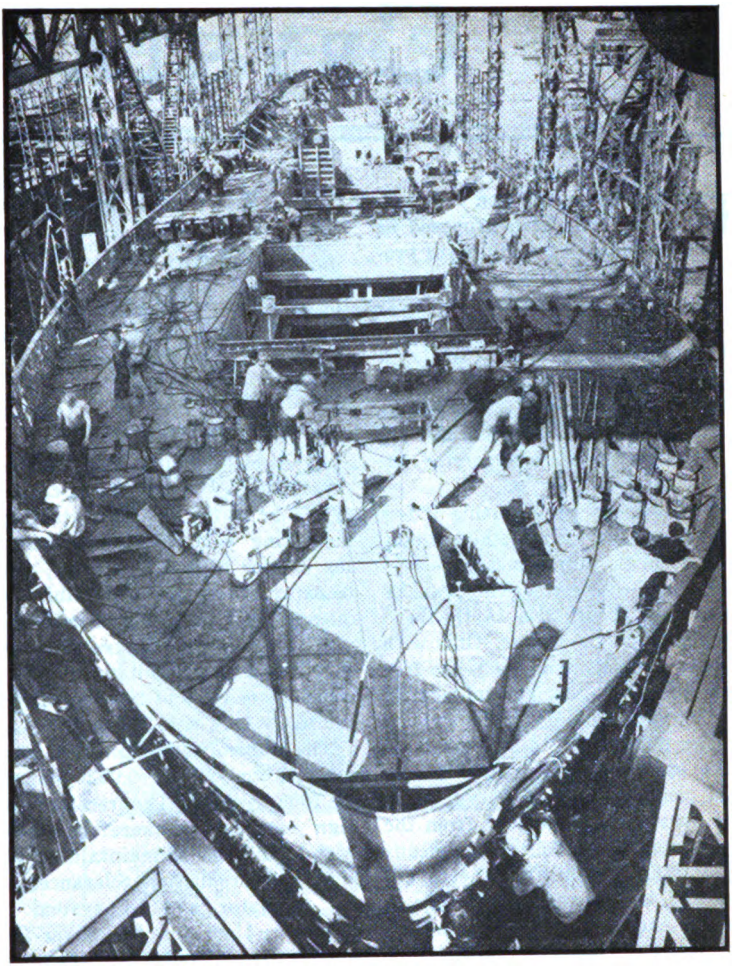
Shoulder-straps are useful for analyzer cases used out in the field. Ladders and scaffolding can be more easily and safely climbed with the analyzer slung from a shoulder.

Spring clips for securing test leads would be a convenience where the open-faced type analyzer is involved. This would prevent loss of the test leads and would also increase the portability of the analyzer.

Some sort of an air-gap shield might be advisable for field-type analyzer-meters. It would tend to "keep" the permanent magnet and would also discourage the migration of metallic dust into the air-gap by reducing the magnet's stray magnetic field.

Analyzer Range Needs

Many commercial analyzers have a low-range ohmmeter scale with a center-scale reading of 30 to 50 ohms, which is too high for most practical work. The center-scale reading should not be more than 10 or 15 ohms, so that resistances of one-tenth or one-eighth-ohm could be easily read. Resistance readings lower than this are not usually required. Terminal-lug, plug, switch and cable-copper series-resistance total up to one or two ohms for frequently encountered cable runs. Where very low resistances must be read in special instances, a Kelvin bridge or Wheatstone bridge should preferably be used.



A typical ship yard, in which test equipment used during the repair of damaged electronic and electrical gear is subjected to necessarily rough usage. Test equipment used in many industrial plants encounters similar conditions

The usual ohmmeter does not have a high enough ohmmeter scale. It should be readable to about five megohms, since some cable specifications call for insulation readings of about five megohms for normal cable lengths and operating temperatures. Such a high-range scale is a convenience and a time-saver, since sectional preliminary ground checks can be made before a final over-all Megger or electronic megohmmeter insulation test is made. The average battery-powered high-range ohmmeter will usually read about one-third to one-fifth too high as compared to the high-voltage insulation testers but will generally show up all low and medium-resistance grounds and leaks.

Most analyzers lack a 500-volt range. There is usually a 750-volt jump from the 250 to the 1,000-volt range. A great deal of the postwar radio and electronic follow-up equipment will probably use amplifier-circuit voltages in the 250 to 500-volt range. The more common use of a 500-volt scale would save many man-hours of test work in the field.

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CRYSTAL-TUNED

By WILLIAM MARON

Senior Radio Engineer
North American Philips Company
Dobbs Ferry, New York

FREQUENCY-modulation broadcasting has been proposed as a greatly improved medium for providing a high-quality transmission of programs, unmarred by background noise, static and man-made electrical interference. While a number of radio engineers take a controversial point of view, f-m is here to stay and has already received promising commercial acceptance.

To fully secure the benefits of f-m it is necessary, among other things, that accurate tuning means be provided in the receiver. The heart of receiver stability lies in the local oscillator and i-f system. Only with proper stability will the noise-free and distortionless capabilities of f-m reception be attained.

The purpose of this paper is to take up engineering and commercial considerations that will show the benefits to be derived from the use of quartz crystals as the means of obtaining stability hitherto unrealized, in a manner practical from design and cost viewpoints and attractive from sales and advertising angles.

When the receiver to be described was designed and built the final f-m allocations were far from settled, consequently it was made for the 42-50 mc f-m band. Some of the necessary changes for operation at the new frequencies will be discussed.

Oscillator and I-F Design

Desirable stability has been expressed as ±0.01 percent of carrier or ±5 kc at 50 mc. This stability, neglecting variations in transmitter carrier center frequency, may be expressed as the permissible frequency drift in the local oscillator over temperature ranges from 40 to 120 F and over humidity conditions between 5 and 100 percent for relatively long periods of time.

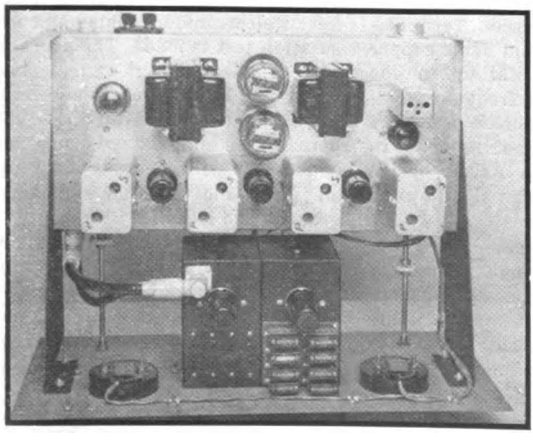
The transmitter channel accuracy is held to within 0.002 percent (±1000 cycles). The receiver design engineer is, therefore, faced with a problem of maintaining design and production tolerances in his oscillator and i-f system to within ±4 kc for the lower-frequency f-m band. At the new higher frequencies, holding the local oscillator to required stability will be even more difficult. To approach this, using a self-excited oscillator, the entire system must make use of closely calibrated capacitors and trimmers having negative temperature coefficient, and low-thermal-expansion materials for coil forms, switch wafers, sockets, etc. Low-expansion metals (Invar or similar) for powdered iron inductance trimmer mountings and/or variable capacitor components are all considerations that, in addition to posing major design difficulties, certainly fall in the category of expensive.

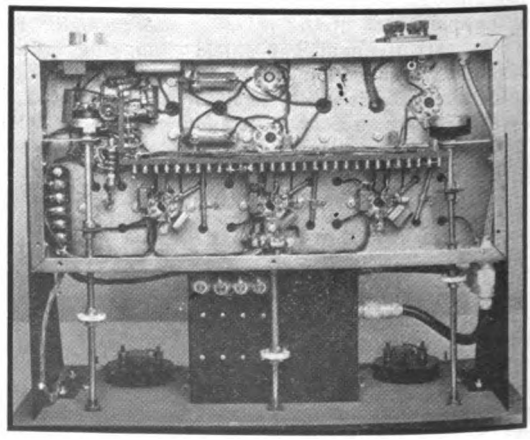
The burden on the design engineer will be considerably reduced if he has readily available an economical and simple means of holding one major section within very close limits. This would apply either to the local oscillator or the i-f channel. Whichever one is easily held within close tolerances obviously allows more leeway in the other.

Advantages of Quartz Crystals

From the above considerations and others which will be explained in detail, it was decided to approach the local oscillator problem by applying quartz crystals in such a manner as to realize their inherent frequency stability.

Quartz wafers may be processed to provide almost inconceivable ac-





Top and bottom views of chassis of laboratory model, 8-station crystal-tuned f-m receiver. Highest-quality parts were used throughout since production engineering was not required

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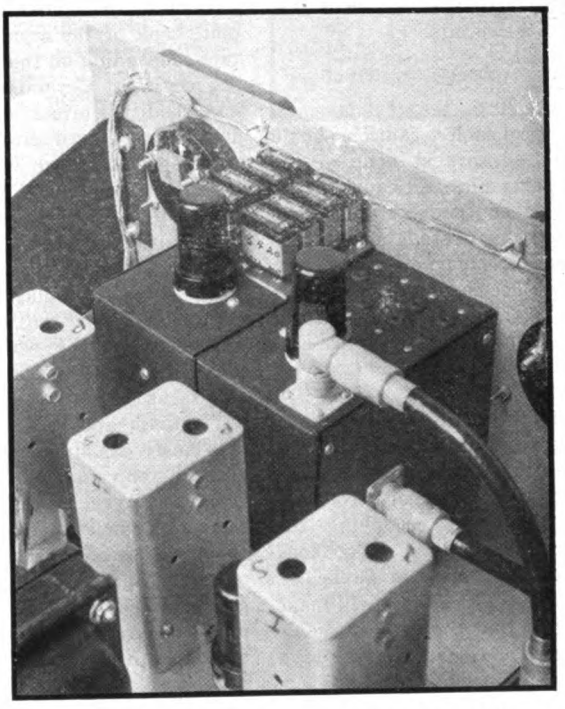
F-M RECEIVERS

Quartz crystals in the oscillator stage of a superheterodyne f-m receiver provide hitherto unrealized stability, make tuning independent of listener skill, and offer other advantages



Closeup of oscillator and mixer stages, in black metal boxes. The plug-in quartz crystals are readily changed. Since two trimmers are associated with each crystal, only two adjustments need be made after a new crystal is inserted

TABLE I. FREQUENCY VALUES FOR NINE-STATION F-M RECEIVER

Station	Freq. in mc	Osc. Freq. in mc	Crystal Freq. in mc
W2XMN	42.8	27.8	5.56
WNYC-FM	43.9	28.9	5.78
WGYN	44.7	29.7	5.94
WEAF-FM	45.1	30.1	6.02
WQXQ	45.9	30.9	6.18
WHNF	46.3	31.3	6.26
WABC-FM	46.7	31.7	6.34
WBAM	47.1	32.1	6.42
WABF	47.5	32.5	6.50

curacy of frequency control. On a laboratory basis, one part in 5 million (0.0002 percent) is common. On a production basis, economical performance can be realized within 0.001 percent, which is 300 cycles at 30 mc. Variations, due to temperature and humidity conditions, result in an additional 0.004 percent—a total deviation of 0.005 percent or roughly 1500 cycles. This allows a margin of ±3 kc overall, a readily obtainable result with standard components.

Other advantages to be realized from the use of quartz crystals in the local oscillator of an f-m circuits are

(1) Most existing f-m receivers are subject to wide drift which during the first half-hour of operation necessitates retuning until temperature stability has been established, and still requires occasional retuning thereafter. The use of quartz control eliminates this undesirable condition, if design considerations outlined above are followed.

(2) Crystal control circuits lend themselves to practical applications of pushbutton or fixed station tuning. This is particularly important in view of the fact that conventional *LC* pushbutton circuits above 20 mc are a major design and manufacturing problem. Furthermore, manual tuning devices for f-m require repeated attention and skill on the part of the user if optimum performance is to be realized. In fact, conventional tuning is impractical unless combined with a suitable (and expensive) tuning indicator device.

(3) From an economic standpoint, the comparative cost of a properly designed 8 or 10-position crystal tuner is not unfavorable when measured against the cost of one manual tuner with proper indicator or pushbutton tuner of conventional design, or a combination of the two. This is particularly true if the advantages and better performance of crystal-controlled circuits are taken into account. In other words, it is possible to justify and even capitalize through sales and advertising on the benefits of crystal operation.

(4) Fixed crystal tuning has sales and service advantages unrealized in conventional types of fixed station tuning.

(5) Factory and service alignment is simplified by using crystals.

Design Data

To illustrate the principle of crystal control, a model receiver operating in the lower-frequency f-m band (42 to 50 mc) was designed and built. For a tuning range of 40 to 50 mc, the i-f band width was ±100 kc, and crystal oscillator stability at the 5th harmonic was better than ±1.5 kc. The overall sta-

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bility (including station drift) was ±8 kc. Audio response was 30 to 15,000 cycles, as checked over the air in cooperation with an f-m station. Overall sensitivity was better than 10 microvolts.

Crystal Frequency Considerations

In selecting the fundamental crystal frequencies, caution should be exercised so that none of the crystal harmonics will equal the i-f value. Other considerations are manufacturing ease, temperature drift, and economy of quartz.

It was decided to use crystals having fundamental frequencies between 5 and 8 mc as they are easily made and are comparatively rugged.

An i-f value of 15 mc was chosen, for reasons to be taken up later. With this i-f value, the local oscillator frequencies needed for f-m stations currently occupying the 42-50 mc band in the New York area are as indicated in Table I.

Inspection of the table will make it apparent that the fifth harmonic of the crystal is used for the local oscillator frequency.

Oscillator Circuit Design

It was necessary to develop a crystal oscillator circuit that would give sufficient output on the fifth harmonic and suppress the adjacent harmonics on either side. This means that the plate circuit of the oscillator must have high Q in order to accentuate the desired and to attenuate the unwanted harmonics.

The complete schematic circuit diagram in Fig. 1 shows the oscillator circuit used. An output of 15 to 20 volts is obtained at the fifth harmonic, measured across the plate tank of the crystal oscillator tube, depending on the activities of the crystals. Crystals with activities readily obtainable in mass production were used throughout.

Considerable time was spent on this particular circuit development. Screen grid and control grid feedback is used to help maintain oscillation. The circuit will oscillate when a crystal is plugged into one of the sockets. Oscillation is not dependent on the setting of the plate LC load. The plate tuned circuit is used only for harmonic accentuation and attenuation, as previously explained.

Oscillator voltage is injected into the control grid of the mixer tube through a small capacitor, the value of which has been chosen to put an optimum voltage on the mixer tube grid for best conversion. Other means of voltage injection may be used, but the above means was expedient. The antenna is fed directly into the mixer grid coil by inductive coupling.

The crystal frequency can readily be determined from the formula $f = (f_c - f_i)/n$, where f is the crystal frequency, f_c is the carrier frequency, f_i is the intermediate frequency, and n is the harmonic order integer applicable.

A three-deck, eight-position rotary switch is incorporated for selecting stations. A rotary switch is used in preference to a pushbutton-type switch for ease of assembly, attainment of shorter leads and self-wiping action obtainable.

Intermediate-Frequency Considerations

Although the present f-m band is only 8 mc wide, FCC reports makes it likely that ultimately an f-m band 30 mc wide will be in existence. The i-f value should be at least half of that width (15 mc) in order to eliminate images within the band, hence 15 mc was chosen for the experimental model.

Another consideration is that the higher the i-f value the lower the oscillator frequency, with the oscillator on the low side of the carrier frequency. The use of a 15-mc i-f value also eliminates the need for an r-f stage ahead of the mixer for suppressing image response. The antenna and tuned input to the mixer grid provide sufficient selectivity.

Construction Details

The laboratory model, multi-station f-m receiver using a crystal-controlled local oscillator was built to study the effects of crystal control on reception of eight f-m stations in the New York area.

Two meters were placed on the panel to make the receiver self-sufficient in that no other test equipment is necessary for alignment. Operating parameters are easily and quickly determined from the meter readings. A rotary selector switch allows either or both meters to be cut out of the circuit.

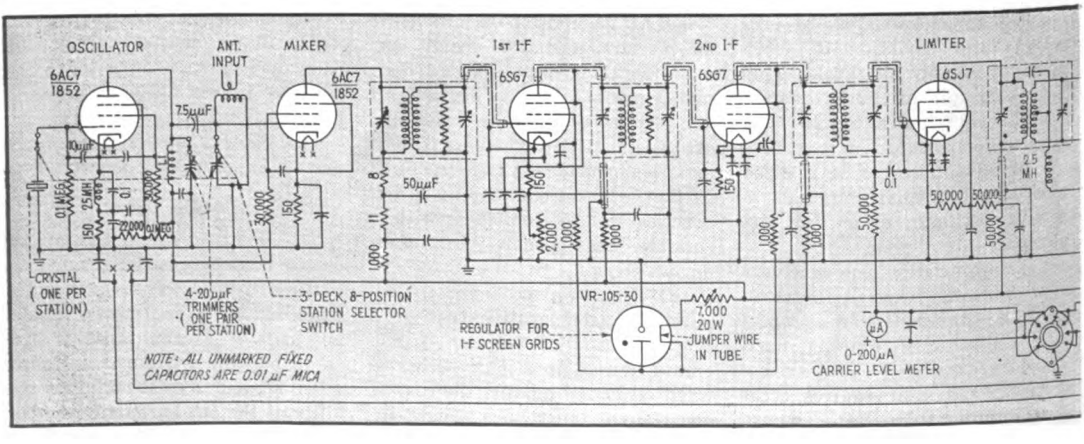

FIG. 1—Schematic circuit diagram of laboratory model crystal-tuned f-m receiver employing an 8-position station

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The crystal oscillator and mixer are built into a separate 6 x 5 x 4-inch metal box, filament and plate power being supplied through ceramic feed-through insulators. Cables and fittings are used for antenna input and for feeding from the mixer plate to the i-f input.

The i-f and audio stages are on a 8 x 17 x 3-inch chassis, with i-f stages built in line along the front, and audio stages occupying the rear of the chassis. Power is supplied from an external source.

The i-f limiter, discriminator and audio stages are conventional and require little explanation.

The unusually large number of mica bypass capacitors is due to the fact that the receiver was designed as a laboratory model, no expense being spared in its construction and no production engineering being done. However, if the power supply is combined on the same chassis, the 0.01-μf filament and power supply bypass capacitors will not be needed. For i-f bypass capacitors, paper may be substituted for mica. However, if oscillations should occur due to the increased inductance of the paper capacitors, mica will have to be used. The use of any paper capacitors in the r-f unit is contraindicated.

Alignment Procedure

During alignment, the 0-200 μa carrier level meter is connected in series with the limiter grid and is used for aligning the i-f amplifier and checking carrier levels of stations. The 50-0-50 μa deviation meter is connected across the discriminator and is used for balancing the discriminator and for observing crystal drift. Alignment of the i-f amplifier is effected by sweep generator methods.

Insert the complement of station crystals. Make sure stations are on the air, rotate the selector switch to the proper channel, and carefully adjust the oscillator trimmer and mixer trimmer for maximum limiter grid current. This is done for each station.

Unless each crystal is on the exact required frequency the discriminator meter will not read zero. The reading for each station will vary plus or minus from zero depending on how far off the crystal happens to be. Movement of this meter reading over a period of time will show crystal drift; station carrier shift will also be indicated, but this may be neglected.

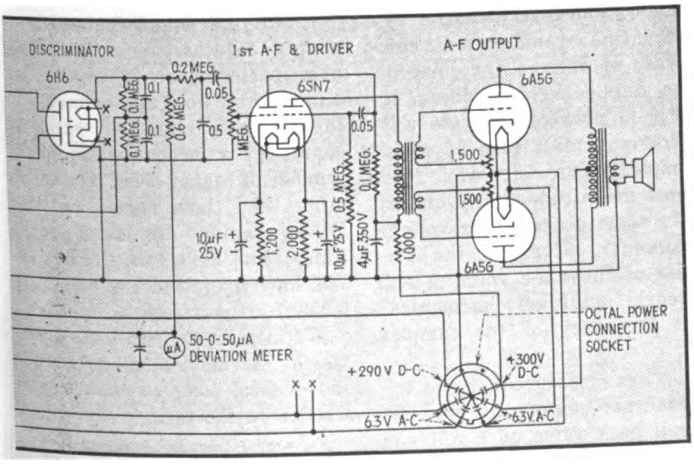
Conclusions

At the time of this writing the above receiver has been in operation every day for over two months. From the time it was initially aligned it has not been touched.

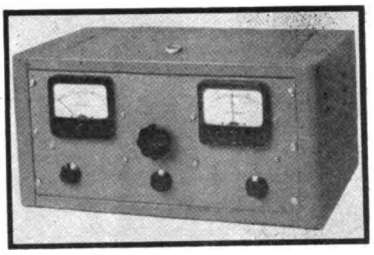
The maximum drift observed has been about 3 kc. This drift is an accumulation of several factors, such as aging, heat, humidity, line voltage fluctuations, and station center frequency deviation.

In order to check drift the reading of the deviation meter must be correctly evaluated.

From a serviceman's point of view, alignment is swift and sure.



selector switch that makes tuning independent of listener skill



Front view of crystal-tuned receiver. Large knob at center controls 8-position rotary selector switch providing instant choice of eight preselected f-m stations

Listeners will have a receiver that will always give them f-m at its best without the need of careful tuning, as there is no tuning. Should the listener move to another area, different crystals can be plugged in to cover stations in the new locality and the r-f trimmers quickly realigned.

Whereas the above analysis has dealt chiefly with the receiver design for the present f-m band (42-50 mc), the considerations shown become of even greater importance in the new band (88-106 mc).

For operation in the higher-frequency band the i-f and audio systems remain the same. The r-f unit will have to be modified. All components comprising the unit should be arranged to result in the shortest possible leads. Heavy wire, such as No. 6 or 8 or small diameter copper tubing, preferably silver plated, will make ideal inductances. Undoubtedly, some of the new high-frequency miniature tubes will give superior performance, especially in the mixer stage.

Summary

Optimum f-m reception requires a high degree of tuning accuracy and stability. The use of quartz crystals in the local oscillator of an f-m receiver is the most economical means of obtaining the desired result while permitting the balance of the receiver to follow conventional lines of design and manufacfacture. In addition, crystal-tuned f-m receivers provide instant, exact, and stable tuning that insures optimum performance independently of the user's skill. Finally, crystal-tuned f-m receivers will be much easier to service and maintain and will minimize the equipment and skill of the serviceman.

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GRAPHICAL A C

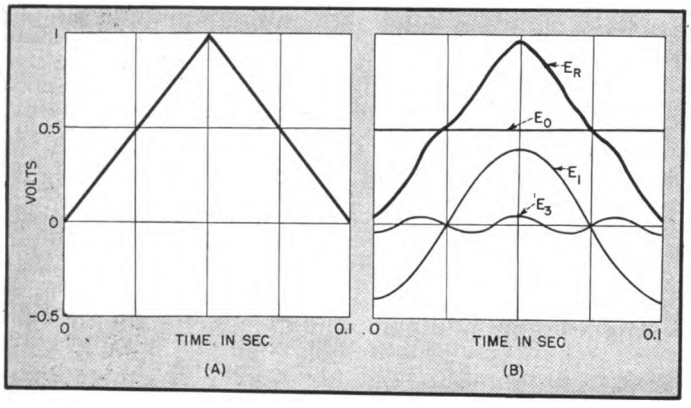

FIG. 1—Example showing how addition of first three principal components E_0, E_1, and E_3 gives a reasonably close approximation E_R to a pure triangular wave

Simple procedure for determining equation of wave and harmonic amplitudes up to the sixth by measuring ordinates on a cathode-ray oscilloscope screen or elsewhere, then substituting measured values in 6, 8, or 12-point schedules requiring only use of arithmetic

By LARRY S. COLE

Department of Radio
Utah State Agricultural College
Logan, Utah

THE determination of the d-c and various a-c components of a complex or distorted wave (such as might be seen on an oscilloscope screen) is frequently of considerable importance and value to both the student and the engineer. The graphical method presented here will yield this information with sufficient detail and accuracy for all ordinary needs, is purely arithmetical, and requires no long or involved calculations.

Principles of Method

Any sine-wave voltage making a specified angle with the time base can be represented by a sine-wave voltage (in phase with the time base) and a cosine-wave voltage (a sine wave 90° out of phase with the time base), each having the proper magnitude. The reason for the utilization of this principle is that often one of the sine-wave components of a complex wave is out of phase with the time base of the complex wave. In the analysis to follow, such a component will appear as a sine and a cosine term, and to obtain the magnitude of the actual component (and its phase angle if desired), these two terms are simply added vectorially.

Any continuous and periodic complex wave of voltage (or current) can be duplicated by adding together a number of separate voltages (or currents), each of which is a simple sine or cosine wave form of proper magnitude and frequency plus, in some cases, a d-c voltage (or current). Further, the frequencies of these a-c voltages will be integral multiples (harmonics) of the frequency of the complex wave.

As an example, consider the triangular wave shown in Fig. 1A having a peak value of 1 volt and a period of 1/10 sec (frequency 10 cycles). The Fourier analysis of this particular wave shows its principal components to be a d-c voltage of 0.5 volt, an a-c voltage of 0.405 volt at 10 cycles with a phase angle of −90°, and an a-c voltage of 0.045 volt at 30 cycles with a phase angle of −90°.

Figure 1B shows the results of adding together these first three principal components, which gives a reasonably good approximation of the original triangular wave. Of course the wave contains an infinite number of higher-order components other than those named, but they are of rapidly decreasing magnitude. (The next two, the 5th and 7th, have magnitudes of 0.0162 and 0.00827 respectively).

We may summarize these principles by stating that the equation of the general complex wave may be written in the form

$$E_R = E_0 + (e_1\sin 2\pi ft + E_1\cos 2\pi ft) + (e_2\sin 2\pi 2ft + E_2\cos 2\pi 2ft) + (e_3\sin 2\pi 3ft) + E_3\cos 2\pi 3ft) + \ldots + (e_n\sin 2\pi nft) + E_n\cos 2\pi nft)$$

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ANALYSIS OF COMPLEX WAVES

where E_0 is the d-c component, $e_1 + jE_1$ is the fundamental a-c component (having the same period as that of the complex wave), $e_2 + jE_2$ is the second harmonic a-c component (having a period one-half that of the complex wave), etc. In a large number of practical cases, we are only interested in the first two or three a-c components of a complex wave because the magnitudes of the higher-order components are small.

Utilizing the above formula and the principles just discussed, let us analyze one cycle of the general complex wave of period $1/f$ sec (frequency f), shown in Fig. 2, for the d-c and first three a-c components.

Analysis of General Complex Wave

First, we divide the period of one cycle of the complex wave ($1/f$ sec) into six equal intervals of $1/6f$ sec each. From the graph, we measure the instantaneous values of the complex wave at these time intervals, noting the respective values as Y_1, Y_2, Y_3, etc., and tabulate as follows:

Time (sec)	$\frac{1}{6f}$	$\frac{2}{6f}$	$\frac{3}{6f}$	$\frac{4}{6f}$	$\frac{5}{6f}$	$\frac{1}{f}$
Inst. values	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6

Since the value of the complex wave at any instant must be equal to the algebraic sum of its components at that instant, we may write the following equations

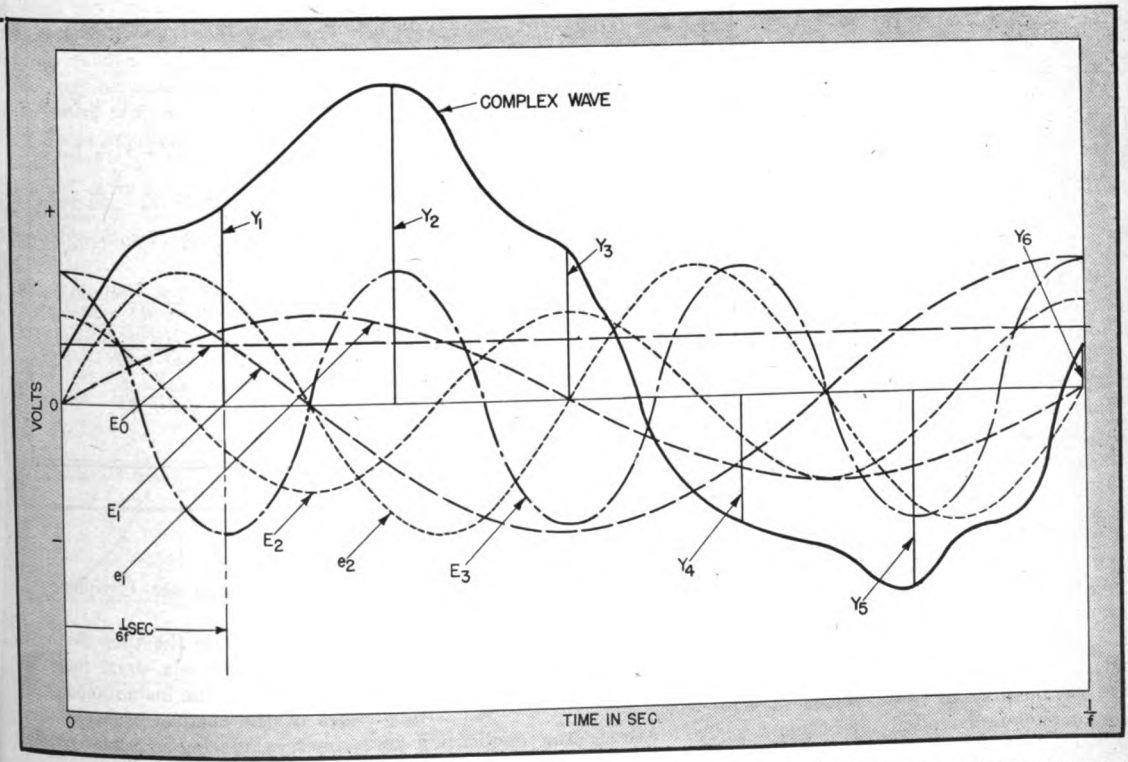

FIG. 2—Complex wave, showing method of measuring ordinates for a six-point analysis. The d-c component and the five sine-wave components are drawn in here only for illustrative purposes without any attempt to show correct amplitudes, and are not needed in the graphical analysis described

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At $t = 1/6f$ sec:

$$E_R = Y_1 = E_0 + e_1\sin 2\pi f \times 1/6f + E_1\cos 2\pi f \times 1/6f + e_2\sin 2\pi \times 2f \times 1/6f + E_2\cos 2\pi \times 2f \times 1/6f + E_3\cos 2\pi \times 3f \times 1/6f$$

At $t = 2/6f$ sec:

$$E_R = Y_2 = E_0 + e_1\sin 2\pi f \times 2/6f + E_1\cos 2\pi f \times 2/6f + e_2\sin 2\pi \times 2f \times 2/6f + E_2\cos 2\pi \times 2f \times 2/6f + E_3\cos 2\pi \times 3f \times 2/6f$$

At $t = 3/6f$ sec:

$$E_R = Y_3 = E_0 + e_1\sin 2\pi f \times 3/6f + E_1\cos 2\pi f \times 3/6f + e_2\sin 2\pi \times 2f \times 3/6f + E_2\cos 2\pi \times 2f \times 3/6f + E_3\cos 2\pi \times 3f \times 3/6f$$

At $t = 4/6f$ sec:

$$E_R = Y_4 = E_0 + e_1\sin 2\pi f \times 4/6f + E_1\cos 2\pi f \times 4/6f + e_2\sin 2\pi \times 2f \times 4/6f + E_2\cos 2\pi \times 2f \times 4/6f + E_3\cos 2\pi \times 3f \times 4/6f$$

At $t = 5/6f$ sec:

$$E_R = Y_5 = E_0 + e_1\sin 2\pi f \times 5/6f + E_1\cos 2\pi f \times 5/6f + e_2\sin 2\pi \times 2f \times 5/6f + E_2\cos 2\pi \times 2f \times 5/6f + E_3\cos 2\pi \times 3f \times 5/6f$$

At $t = 1/f$ sec:

$$E_R = Y_6 = E_0 + e_1\sin 2\pi f \times 1/f + E_1\cos 2\pi f \times 1/f + e_2\sin 2\pi \times 2f \times 1/f + E_2\cos 2\pi \times 3f \times 1/f$$

These six equations become, after simplification and substitution of trigonometric values

$$Y_1 = E_0 + (1/2)E_1 + (\sqrt{3}/2)e_1 - (1/2)E_2 + (\sqrt{3}/2)e_2 - E_3$$

$$Y_2 = E_0 - (1/2)E_1 + (\sqrt{3}/2)e_1 - (1/2)E_2 - (\sqrt{3}/2)e_2 + E_3$$

$$Y_3 = E_0 - E_1 + E_2 - E_3$$

$$Y_4 = E_0 - (1/2)E_1 - (\sqrt{3}/2)e_1 - (1/2)E_2 + (\sqrt{3}/2)e_2 + E_3$$

$$Y_5 = E_0 + (1/2)E_1 - (\sqrt{3}/2)e_1 - (1/2)E_2 - (\sqrt{3}/2)e_2 - E_3$$

$$Y_6 = E_0 + E_1 + E_2 + E_3$$

We now have six linear simultaneous equations containing six unknowns E_0, E_1, e_1, E_2, e_2, and E_3. (The Y values are known, having been measured from the graph.) When solved, these equations give the values set forth in Table I for a six-point analysis. Corresponding formulas for the eight and twelve-point methods, also given in Table I, are derived in the same manner and are used when it is necessary to take a greater number of points in order to secure more detailed and accurate results. The d-c, fundamental, and harmonic components are obtained from these values in the manner indicated at the bottom of the table.

The phase angles of the various a-c components with the time base of the complex wave are generally of no interest, but may be obtained from the complex notations if desired.

TABLE I. SCHEDULES FOR GRAPHICAL ANALYSIS OF COMPLEX WAVES

SIX-POINT SCHEDULE—for d-c, 1st, 2nd, and 3rd harmonics

$$E_0 = (1/6)(Y_1 + Y_2 + Y_3 + Y_4 + Y_5 + Y_6)$$
$$E_1 = (1/6)(Y_1 - Y_2 - Y_4 + Y_5) + (1/3)(-Y_3 + Y_6)$$
$$e_1 = (\sqrt{3}/6)(Y_1 + Y_2 - Y_4 - Y_5)$$
$$E_2 = (1/6)(-Y_1 - Y_2 - Y_4 - Y_5) + (1/3)(Y_3 + Y_6)$$
$$e_2 = (\sqrt{3}/6)(Y_1 - Y_2 + Y_4 - Y_5)$$
$$E_3 = (1/6)(-Y_1 + Y_2 - Y_3 + Y_4 - Y_5 + Y_6)$$

EIGHT-POINT SCHEDULE — for d-c, 1st, 2nd, 3rd, and 4th harmonics

$$E_0 = (1/8)(Y_1 + Y_2 + Y_3 + Y_4 + Y_5 + Y_6 + Y_7 + Y_8)$$
$$E_1 = (\sqrt{2}/8)(Y_1 - Y_3 - Y_5 + Y_7) + (1/4)(-Y_4 + Y_8)$$
$$e_1 = (\sqrt{2}/8)(Y_1 + Y_3 - Y_5 - Y_7) + (1/4)(Y_2 - Y_6)$$
$$E_2 = (1/4)(-Y_2 + Y_4 - Y_6 + Y_8)$$
$$e_2 = (1/4)(Y_1 - Y_3 + Y_5 - Y_7)$$
$$E_3 = (\sqrt{2}/8)(-Y_1 + Y_3 + Y_5 - Y_7) + (1/4)(-Y_4 + Y_8)$$
$$e_3 = (\sqrt{2}/8)(-Y_1 + Y_3 - Y_5 - Y_7) + (1/4)(-Y_2 + Y_6)$$
$$E_4 = (1/8)(-Y_1 + Y_2 - Y_3 + Y_4 - Y_5 + Y_6 - Y_7 + Y_8)$$

TWELVE-POINT SCHEDULE—for d-c, 1st, 2nd, 3rd, 4th, 5th, and 6th harmonics

$$E_0 = (1/12)(Y_1 + Y_2 + Y_3 + Y_4 + Y_5 + Y_6 + Y_7 + Y_8 + Y_9 + Y_{10} + Y_{11} + Y_{12})$$
$$E_1 = (\sqrt{3}/12)(Y_1 - Y_5 - Y_7 + Y_{11}) + (1/12)(Y_2 - Y_4 - Y_8 + Y_{10}) + (1/6)(-Y_6 + Y_{12})$$
$$e_1 = (1/12)(Y_1 + Y_5 - Y_7 - Y_{11}) + (\sqrt{3}/12)(Y_2 + Y_4 - Y_8 - Y_{10}) + (1/6)(Y_3 - Y_9)$$
$$E_2 = (1/12)(Y_1 - Y_2 - Y_4 + Y_5 + Y_7 - Y_8 - Y_{10} + Y_{11}) + (1/6)(-Y_3 - Y_9 + Y_{12})$$
$$e_2 = (\sqrt{3}/12)(Y_1 + Y_2 - Y_4 - Y_5 + Y_7 + Y_8 - Y_{10} - Y_{11})$$
$$E_3 = (1/6)(-Y_2 + Y_4 - Y_6 + Y_8 - Y_{10} + Y_{12})$$
$$e_3 = (1/6)(Y_1 - Y_3 + Y_5 - Y_7 + Y_9 - Y_{11})$$
$$E_4 = (1/12)(-Y_1 - Y_2 - Y_4 - Y_5 - Y_7 - Y_8 - Y_{10} - Y_{11}) + (1/6)(Y_6 + Y_9 + Y_{12})$$
$$e_4 = (\sqrt{3}/12)(Y_1 - Y_2 + Y_4 - Y_5 + Y_7 - Y_8 + Y_{10} - Y_{11})$$
$$E_5 = (\sqrt{3}/12)(-Y_1 + Y_5 + Y_7 - Y_{11}) + (1/12)(Y_2 - Y_4 - Y_8 + Y_{10}) + (1/6)(-Y_6 + Y_{12})$$
$$e_5 = (1/12)(Y_1 + Y_5 - Y_7 - Y_{11}) + (\sqrt{3}/12)(-Y_2 - Y_4 + Y_8 + Y_{10}) + (1/6)(Y_3 - Y_9)$$
$$E_6 = (1/12)(-Y_1 + Y_2 - Y_3 + Y_4 - Y_5 + Y_6 - Y_7 + Y_8 - Y_9 + Y_{10} - Y_{11} + Y_{12})$$

SIGNIFICANCE OF NOTATIONS

D-c component = E_0

Fundamental a-c component = $e_1 + jE_1$; peak value = $\sqrt{e_1^2 + E_1^2}$

Second harmonic a-c component = $e_2 + jE_2$; peak value = $\sqrt{e_2^2 + E_2^2}$

Third harmonic a-c component = $e_3 + jE_3$; peak value = $\sqrt{e_3^2 + E_3^2}$

Fourth harmonic a-c component = $e_4 + jE_4$; peak value = $\sqrt{e_4^2 + E_4^2}$

Fifth harmonic a-c component = $e_5 + jE_5$; peak value = $\sqrt{e_5^2 + E_5^2}$

Sixth harmonic a-c component = E_6 (peak value)

Example 1

To illustrate the application of the formulas just developed for a six-point analysis, let us analyze the complex wave of Fig. 3, whose period is 1/10 sec (frequency cycles).

First, divide the time period one cycle into six equal intervals and measure the instantaneous values of the complex wave at these times, tabulating as follows:

Points	Y_1	Y_2	Y_3	Y_4	Y_5
Values	2	4	1	-1	-2

Substituting these values in the

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point formulas in Table I, we obtain

$E_0 = (1/6)(2+4+1-1-2+1) = 0.833$

$E_1 = (1/6)(2-4+1-2) + (1/3)(-1+1) = -0.5$

$e_1 = (\sqrt{3}/6)(2+4+1+2) = 2.6$

$E_2 = (1/6)(-2-4+1+2) + (1/3)(1+1) = 0.167$

$e_2 = (\sqrt{3}/6)(2-4-1+2) = -0.289$

$E_3 = (1/6)(-2+4-1-1+2+1) = 0.5$

The results of the analysis are

D-c component = E_0 = 0.833 volt
Fundamental a-c component (10 cycles) = 2.6 − j 0.5 = 2.65 volts (peak)
Second harmonic a-c component (20 cycles) = −0.289 + j 0.167 = 0.333 volt (peak)
Third harmonic a-c component (30 cycles) = E_3 = 0.5 volt (peak)

Example 2

As a further illustration of the method, let us apply the twelve-point analysis to the output waveform of a 60-cycle half-wave rectifier output having a peak value of 100 volts. The graph of this wave form is shown in Fig. 4.

Note that the period of a complete cycle of this particular wave extends along the time base from $t = 0$ to $t = 1/60$ sec. Divide this time of one complete cycle into twelve equal intervals (1/720 sec), measure the instantaneous values of the wave at these times, and tabulate as follows (in this case the values may be calculated inasmuch as the wave is exactly half a sine wave whose equation is known)

Points	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6-Y_{12}
Values	50	86.6	100	86.6	50	0

Substituting these values into the twelve-point formulas of Table I gives

$E_0 = (1/12)(50+86.6+100+86.6+50) = 31.1$

$E_1 = (\sqrt{3}/12)(50-50) + (1/12) \times (86.6-86.6) = 0$

$e_1 = (1/12)(50+50) + (\sqrt{3}/12) \times (86.6+86.6) + (1/6)(100) = 50.0$

$E_2 = (1/12)(50-86.6-86.6+50) + (1/6)(-100) = -22.8$

$e_2 = (\sqrt{3}/12)(50+86.6-86.6-50) = 0$

$E_3 = (1/6)(-86.6+86.6) = 0$

$e_3 = (1/6)(50-100+50) = 0$

$E_4 = (1/12)(-50-86.6-86.6-50) + (1/6)(100) = -6.09$

$e_4 = (\sqrt{3}/12)(50-86.6+86.6-50) = 0$

$E_5 = (\sqrt{3}/12)(-50+50) + (1/12) \times (86.6-86.6) = 0$

$e_5 = (1/12)(50+50) + (\sqrt{3}/12) \times (-86.6-86.6) + (1/6)(100) = 0$

$E_6 = (1/12)(-50+86.6-100+86.6-50) = -2.23$

As in the previous example, these results simplify to

D-c component = E_0 = 31.1 volts
Fundamental a-c component = 50.0 volts (60 cycles)
Second harmonic component = 22.8 volts
Third harmonic component = 0
Fourth harmonic component = 6.1 volts
Fifth harmonic component = 0
Sixth harmonic component = 2.23 volts

The Fourier analysis for this same wave shows the respective values of the components to be 31.8, 50.0, 21.2, 4.24 and 1.82 volts. A comparison with the values obtained with the graphical method above shows good correlation. It should be noted here that the Fourier analysis can only be applied when the equation of the wave is known or can be pieced together, while the graphical method may be applied in all cases.

The following rules and suggestions will prove of value in applying the graphical analysis.

1. Be certain to take a full cycle of the complex wave to apply the analysis. The choice of the starting and end points is not important so long as they cover the interval of an entire cycle.

2. All values of a-c components in the analysis are peak values.

3. In certain cases, where a sort of symmetry exists in the wave, the d-c and/or certain of the a-c components may be zero.

4. Frequently, we are not interested in absolute values of the components, but relative ones with respect to the complex wave. In these cases, any arbitrary scale of values may be assigned to the complex wave and the values of the components expressed as percentages.

5. The values of the components of a given wave obtained by the 6, 8 or 12-point method may differ somewhat, becoming more accurate as a greater number of points are taken. In a sense, we may look on the Fourier analysis as one taking an infinite number of points.

6. Should the phase angle of any of the a-c components be desired, it will be given as arctan e/E. Further, it should be noted that one cycle of the complex wave represents 360° at the fundamental frequency, 720° at the second harmonic, etc.

7. The usual care in the observation of algebraic signs should be taken when measuring the Y values and substituting them into the formulas.

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(1) Hutcheson, J. A., Graphical Harmonic Analysis, ELECTRONICS, Jan., 1936, p. 16. Description of method applicable to waves of the type where there are sine components of odd harmonics and cosine components of even harmonics, as in amplifiers or modulators.

(2) Denman, R. P. G., 36 and 72 Ordinate Schedules for General Harmonic Analysis, ELECTRONICS, Sept., 1942, p. 44. Systematization of procedure facilitates the tedious calculations required in harmonic analysis of complex waves. The schedules, with equations for checking results, are applicable to use with odd and even harmonics.

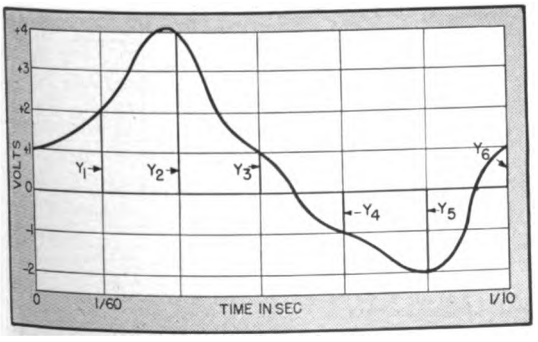

FIG. 3—Complex wave analyzed in Example 1 by means of the six-point schedule in Table I

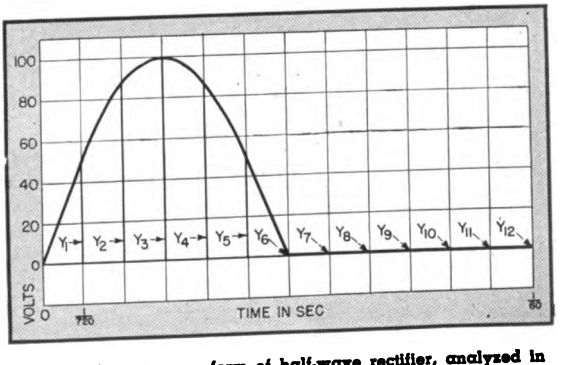

FIG. 4—Output wave form of half-wave rectifier, analyzed in Example 2 by means of the twelve-point schedule

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Reactor Measurements

Current feedback creates high-impedance source from which resonant circuit containing saturable core inductor can be fed both a-c and d-c for measurement of inductor's electrical parameters. Circuit provides coupling for test oscillator and vacuum-tube voltmeter

By **HOWARD L. DANIELS**
Naval Ordnance Laboratory
Washington, D. C.

AN INDUCTANCE used in a vacuum-tube circuit is often required to carry a direct current. If the magnetic circuit includes iron, permalloy, or any of the other saturable core materials, the presence of the direct current may profoundly modify the L and Q of the coil to the superimposed a-c signal. These properties are also functions of signal level and frequency, and are adequately described only when their dependence on all three of these variables has been investigated.

Possible Measurement Methods

Measurement of the properties of the inductance under such conditions can sometimes be made by paralleling the coil with a capacitor, feeding the direct current and the a-c signal to the parallel circuit through a series resistor, and investigating the shape of the parallel impedance curve as a function of either frequency or parallel capacitance. However, if the shape of the curve is not to be seriously affected by the driving circuit, the resistance must be large compared to the parallel circuit impedance at resonance; and if the L and Q of the coil are even moderately high by present standards, the voltage and power consumed by the series resistor may be prohibitive.

A method applicable in some cases is to supply the signal and saturating current through the plate of a pentode, but even the relatively high pentode plate impedance is often inadequate for the purpose. A simple triode may be given a high apparent output impedance by inserting an unbypassed resistor in its cathode circuit, but the usefulness of this method is similarly limited.

Feedback Circuit

A vacuum tube circuit which is well suited for nearly all measurements of this type in the frequency range 20—100,000 cps is shown in Fig. 1. This circuit provides a direct coil current which is contin-

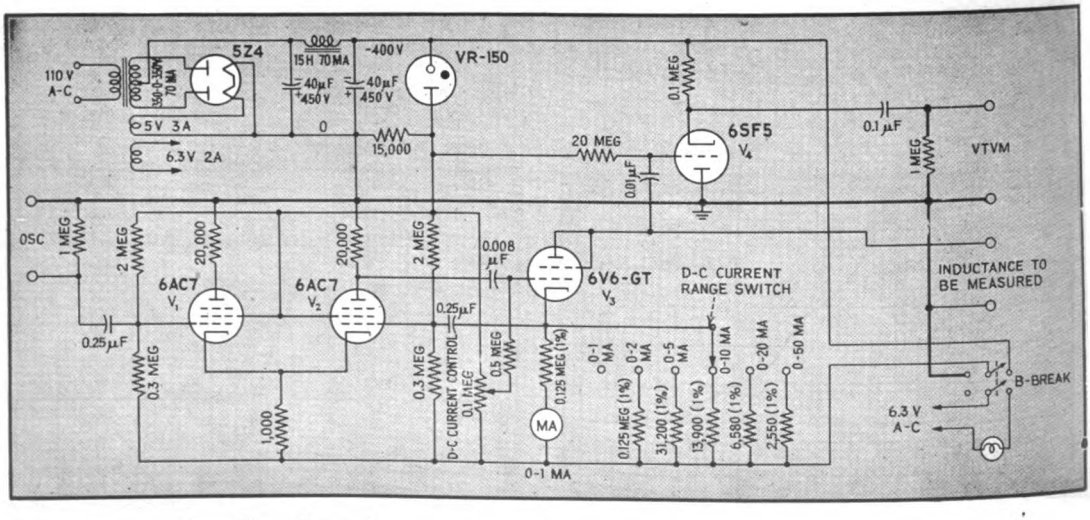

FIG. 1—Circuit for supplying a-c and d-c to reactors for measurement of their characteristics

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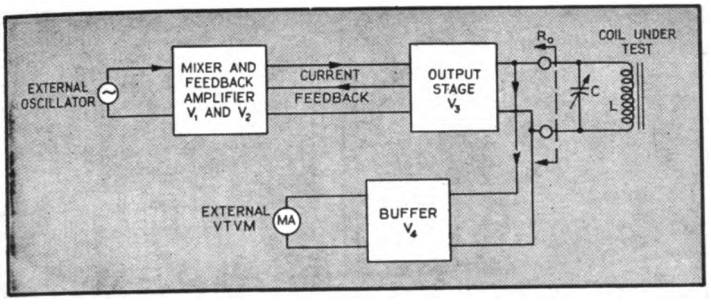

Test set for reactor measurements consists of an oscillator injector, a high-impedance output stage, and a vtvm buffer

uously adjustable from 0.3 ma to 50 ma, with an a-c output impedance between 2.5 megohms and 90 megohms, depending on the selected current range. High a-c output impedance is achieved by application of a large amount of current feedback, with dissipation of only a small fraction of the power and voltage that would be required to obtain similar results by any of the means mentioned above.

The output stage V_3, through which both saturating current and test signal are applied to the inductance, is a triode-connected 6V6-GT. The direct current is controlled by a range selector switch, which inserts various fixed resistors in series with the cathode, and a potentiometer, which permits the d-c voltage between the grid and B– to be varied continuously from 0 to 150 volts. A milliammeter is provided in the cathode circuit of V_3 to indicate the direct current.

If a signal were applied directly to the grid of the output stage, the apparent output impedance R_o would be the sum of plate resistance r_p and the a-c cathode circuit resistance R_{ac}, plus a current feedback component equal to μR_{ac}, the latter being by far the largest part of the total. In this circuit, however, and signal developed across R_c is amplified by the gain N of V_3 and applied in opposite phase to the grid of the output tube. This effectively increases the current feedback component of the output impedance by a factor $(N-1)$. Thus the output impedance $R_o = r_p + R_c + \mu(N-1)R_c = \mu N R_c$ approximately.

Injection and Buffer Stages

The test signal is injected into the circuit through the cathode of V_3, which is coupled directly to, and driven by, the cathode of V_1. This system reduces the gain of V_3 by a factor of two, but is superior to other possible methods from the standpoints of simplicity and stability. To the extent that the gain between the grid of V_3 and the cathode of V_3 is large, the voltage across R_c is constrained to follow the oscillator voltage, and V_3 acts as a constant-current source, giving a signal current $i_o = e_{osc}/R_c$ approximately.

The effect of the impedance of the parallel circuit under test is to diminish this gain, and hence to reduce i_o; which is simply another way of stating that the output of V_3 may be taken as a constant current source only when R_c is large compared to the impedance of the circuit under test. In any case, the equivalent circuit of Fig. 2(A) applies. The above expression for i_o is not entirely accurate, since e_{osc} suffers a slight loss between the grid of V_1 and the cathode of V_3. Values of i_o which take this loss into account are listed in Table I. They were checked experimentally and found to be within five percent of the measured values. They are of occasional use for direct calculation of resonant circuit impedances.

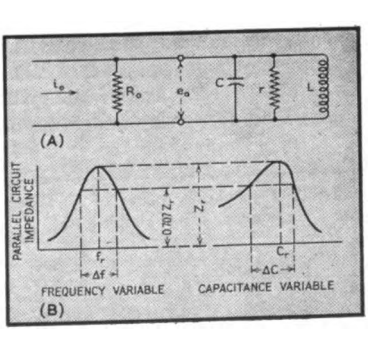

FIG. 2—(A) Equivalent circuit of driver and test circuit, and (B) the significant dimensions of the resonance curves from which inductance, resistance and quality of the inductor can be computed

It may be pointed out that a double triode might be substituted for V_1 and V_3 with appropriate circuit redesign but only at a sacrifice in output impedance or high-frequency response, or both.

The buffer stage is simply a cathode follower which prevents the input impedance of the external vacuum-tube voltmeter or oscilloscope used in tracing the parallel-circuit impedance curve from loading the parallel circuit, and hence affecting the results of the measurement. The total stray capacitance from the plate of V_3 to ground is limited to about 15 $\mu\mu$f by this means, and the added shunt resistance is about 500 megohms.

The grounding of B+ rather than B– provides some protection against shock while manipulating the coil under test. As an additional safeguard, a switch is provided which breaks B–, and also operates a pilot light to indicate its position at all times. Whenever the d-c coil circuit is to be broken, this switch is first operated to protect the operator from the negative supply voltage.

Method of Measurement

Characteristics of the inductance are most conveniently determined by studying the impedance curve of the inductance under test in parallel with a known capacitance, either as a function of variable frequency or of variable capacitance as indicated in Fig. 2(B). Inductance is readily calculated from $L = 1/(2\pi f_r)^2 C_r$.

The value of Q may be evaluated

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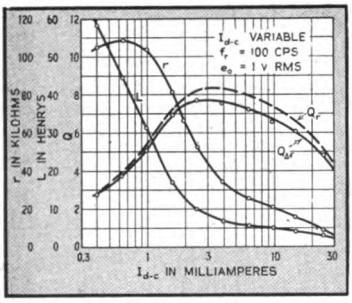

FIG. 3—Variation of inductor parameters with d-c magnetization can be readily measured

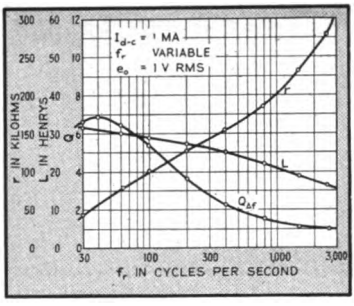

FIG. 4—Iron-cored inductor characteristics vary greatly with frequency the Q having a maximum

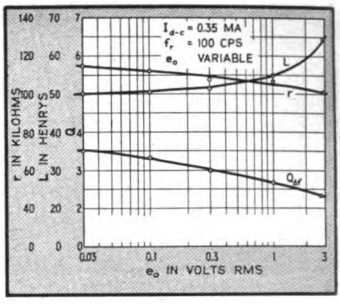

FIG. 5—Alternating signal amplitude, as well as frequency and dc affect reactor parameters

from the width of the impedance curve between the points of 70.7 percent of the peak impedance. For frequency detuning, $Q_{\Delta f} = f_r/\Delta f$; for capacitance detuning, $Q_{\Delta c} = 2C_r/\Delta C$.

The resonant impedance r of the parallel circuit can be calculated directly from e_o/i_o evaluated at resonance, where e_o is measured by the external vtvm, and i_o is found from e_{oo} and the value of i_o/e_{oo} given in Table I.

The error which can result from the shunting effect of R_o on the parallel circuit is readily evaluated as follows. The value of Q for the parallel circuit is defined as $Q_r = r/X$ where $X = 2\pi f_r L = 1/(2\pi f_r)C$. The value actually measured by either of the above procedures is $Q = [rR_o/(r + R_o)]/X$. Combining these two equations gives $Q_r = Q/(1 - QX/R_o)$. Normally, this circuit provides a value of R_o sufficiently high as compared with the parallel circuit resonant impedance QX to make the correction negligible.

The above discussion assumes that the losses in the capacitor are small compared to those in the coil, and care must be taken to insure that this is the case; that is, the capacitance power factor must be small as compared to $1/Q$.

Inductor Measurements

Examples of data obtainable from the circuit and calculations outlined above are presented graphically in Fig. 3, 4, and 5. The independent variables for these curves are respectively the direct coil current $I_{d\text{-}c}$, the resonance frequency f_r of the parallel circuit, and the rms signal voltage e_o developed across the coil. The test specimen for these curves was an audio-frequency choke having a core of closely interleaved laminations of a high-permeability nickel-iron alloy.

The saturating effect of a direct coil current is shown by Fig. 3 to be roughly equivalent to the introduction of an air-gap in the magnetic circuit. As the direct current increases, the value of the inductance decreases. Increasing saturation also reduces the core losses, in this case at such a rate relative to the drop in inductance that the value of Q has a peak in the region of $I_{d\text{-}c} =$ 3 ma. The resonant circuit impedance also has a peak value, but at a lower value of direct current.

The curves representing Q in Fig. 3 are derived from the relations $Q_r = r/2\pi f_r L$, and $Q_{\Delta f} = f_r/\Delta f$. That slight discrepancies exist between corresponding points on the two curves is not surprising because the equivalent circuit of Fig. 2(A) is only a simplifying approximation, even though it yields results which are sufficiently accurate for most purposes. Moreover, both r and L are variable with changes in frequency and in signal level; and the frequency-increment measurement of Q, which involves changes of both kinds, cannot be expected to agree exactly with the definitive relation $Q = r/2\pi f_r L$. Sharpness of the resonance curve with respect to frequency is usually of primary interest, however, and the results of the frequency-increment determination therefore provide the best description of performance.

TABLE I — Relative values of i_o, taking into account test circuit losses

D-C range in ma	R_o in megohms	i_o/e_{oo} in ma/v
1	90	0.010
2	50	0.017
5	23	0.038
10	12	0.075
20	6	0.14
50	2.5	0.35

The value of Q also has a maximum with respect to frequency, as shown in Fig. 4. At low frequencies, losses are relatively large because of the flow of a heavy magnetizing current through the coil resistance; at high frequencies, the losses again become large because of the rapid increase of core losses. The gradual reduction in L throughout the represented range of frequencies is attributable to an effective reduction in the cross-sectional area of the core by the eddy currents. The resonance impedance r rises throughout this frequency range, but might be expected to drop at frequencies for which the charging currents required by the distributed coil capacitance again causes the copper loss to predominate.

The increase in inductance with signal level shown in Fig. 5, which is typical of ferromagnetic core materials, results from the initial upward curvature of the B-H characteristic. The application of a sufficiently high signal voltage to work the core above the saturation knee of the magnetization curve will, of course, reverse this trend and cause the inductance to drop sharply.

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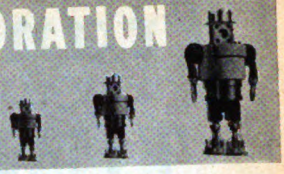
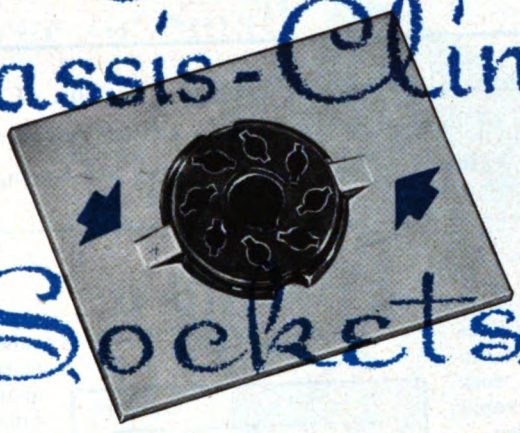
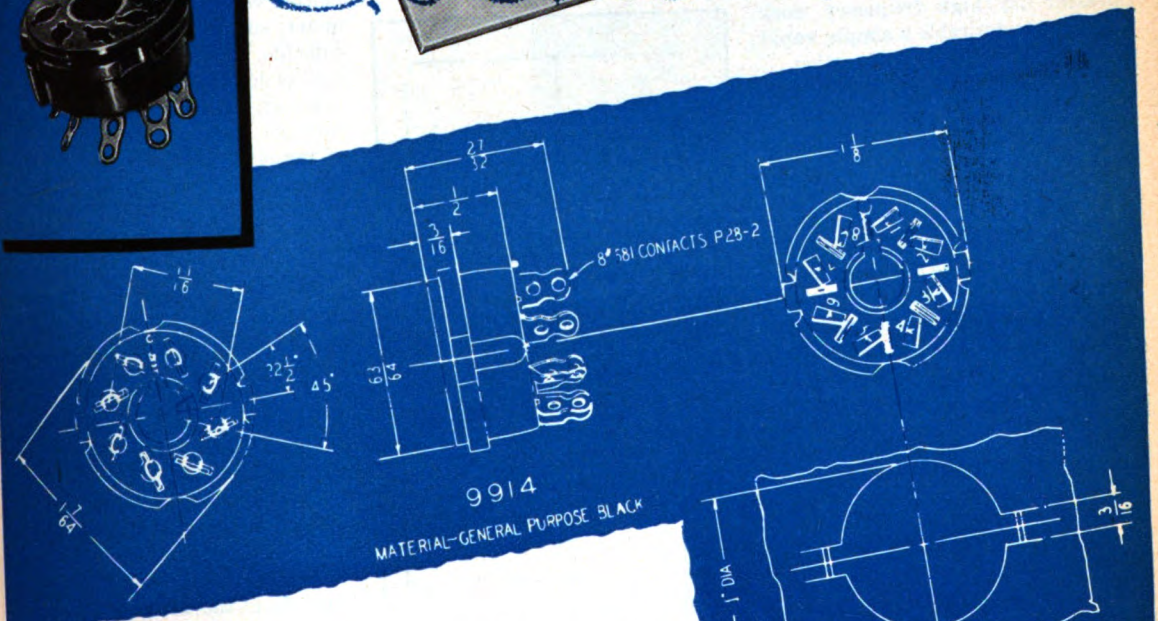


Octal Chassis-Clinch Sockets





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Transmission Lines as TUNING ELEMENTS

Graph for designing tuning element consisting of a section of transmission line shunted by a capacitor. Values of one or two unknown circuit parameters may be found when values of two or three others are known

By H. E. NEWELL, JR.
Naval Research Laboratory
Washington, D. C.

SEGMENTS of transmission lines used as circuit elements in present day high frequency work have made desirable a simple, rapid method for solving the equation

$$1/\omega C = Z_0 \tan 2\pi l/\lambda, \; l \leq \lambda/4 \qquad (1)$$

The equation gives the wave length λ of the resonant frequency $\omega/2\pi$ of a parallel combination of a capacitance C and a short circuited length l of transmission line of characteristic impedance Z_0, shown in Fig. 1.

The graph on the next page shows two sets of contours, the plots of which are superimposed upon each other in such a manner as to afford a convenient means for solving Eq. 1 graphically. The discussion below contains a brief outline of the construction of the graph, followed by its application to the solution of two typical problems.

Construction of the Graph

Rewrite Eq. 1, by using the relations $\omega = 2\pi f$ and $\lambda = v_0/f$, where f is frequency in cycles per second, and $v_0 = 3 \times 10^8$ meters per second, the propagation constant.

$$1/Z_0C = 2\pi f \tan (2\pi fl/v_0) \qquad (2)$$

Equation 2 may be applied to the circuit of Fig. 1 by expressing Z_0 in ohms, C in farads, f in cycles per second, and l in meters.

But if Z_0 is in ohms, C in $\mu\mu$f, f in mc, and l in cm, Eq. 2 becomes

$$\frac{1}{Z_0 \times 10^{-12} C} = 2\pi 10^6 f \tan \frac{2\pi 10^6 f \left(\frac{l}{100}\right)}{3 \times 10^8}$$

$$\frac{10^8}{Z_0 C} = \frac{2\pi f}{10^2} \tan \frac{2\pi fl}{3 \times 10^4} \qquad (3)$$

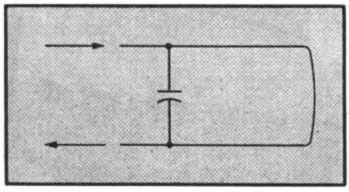

FIG. 1—Short-circuited transmission line of length l, and characteristic impedance Z_0 tuned by shunt capacitance

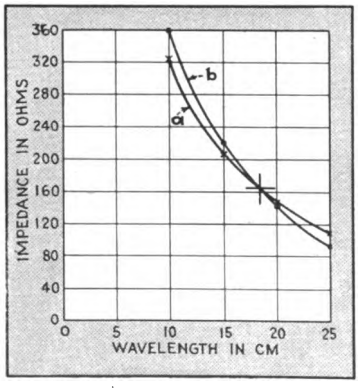

FIG. 2—Graphical solution for Eq. 1, where two quantities are unknown

or

$$F_2(Z_0, C) = F_1(l, f)$$

where

$$F_1(l, f) \equiv (2\pi f/10^2) \tan (2\pi fl/3 \times 10^4)$$

and

$$F_2(Z_0, C) \equiv 10^8/Z_0 C$$

On logarithmic graph paper, plot $F_1(l, f)$ against l for the various values of f. Upon these contours superimpose those of $F_2(Z_0, C)$ plotted versus C with Z_0 as a parameter, so that the F_1 and F_2 scales coincide. The C and l scales coincide as do the F_1 and F_2 scales. This, however, is not necessary, and in this case is due merely to the choice of range for the values of C. It is essential that the F_1 and F_2 scales be identical.

Use of the Chart

The construction of the chart makes evident the general principles involved in its use. A solution is obtained for Eq. 3, by making $F_1(l, f) = F_2(Z_0, C)$. Suppose that a 10 cm line of 50 ohms characteristic impedance is to be tuned to resonance at 400 mc by shunting a lumped capacitance C across the input and short circuiting the other end.

To find C, the solution is as follows: from the 10 cm point on the l scale of the graph move vertically to the $F_1(l, f)$ contour marked 400 mc. Then move horizontally to the $F_2(Z_0, C)$ contour labelled 50 ohms. From this point move vertically again to the C scale and read off the capacitance, 7.3 $\mu\mu$f.

If any three of the quantities l, Z_0, C, f in Eq. 3 be given, the fourth is obtanied by a procedure similar to that used above. If two of quantities be given, the remaining two can assume infinitely many pairs of values satisfying Eq. 3.

Consider now the problem of a shorted open wire line to be used as

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a circuit element in a high frequency amplifier. A variable capacitance, ranging from 5 $\mu\mu$f to 10 $\mu\mu$f, is shunted across the open end of the line and used for tuning. If the frequency range to be tuned is from 150 mc to 200 mc, what should the physical length and characteristic impedance of the line be?

Mathematically this problem is that of solving simultaneously two equations in two unknowns

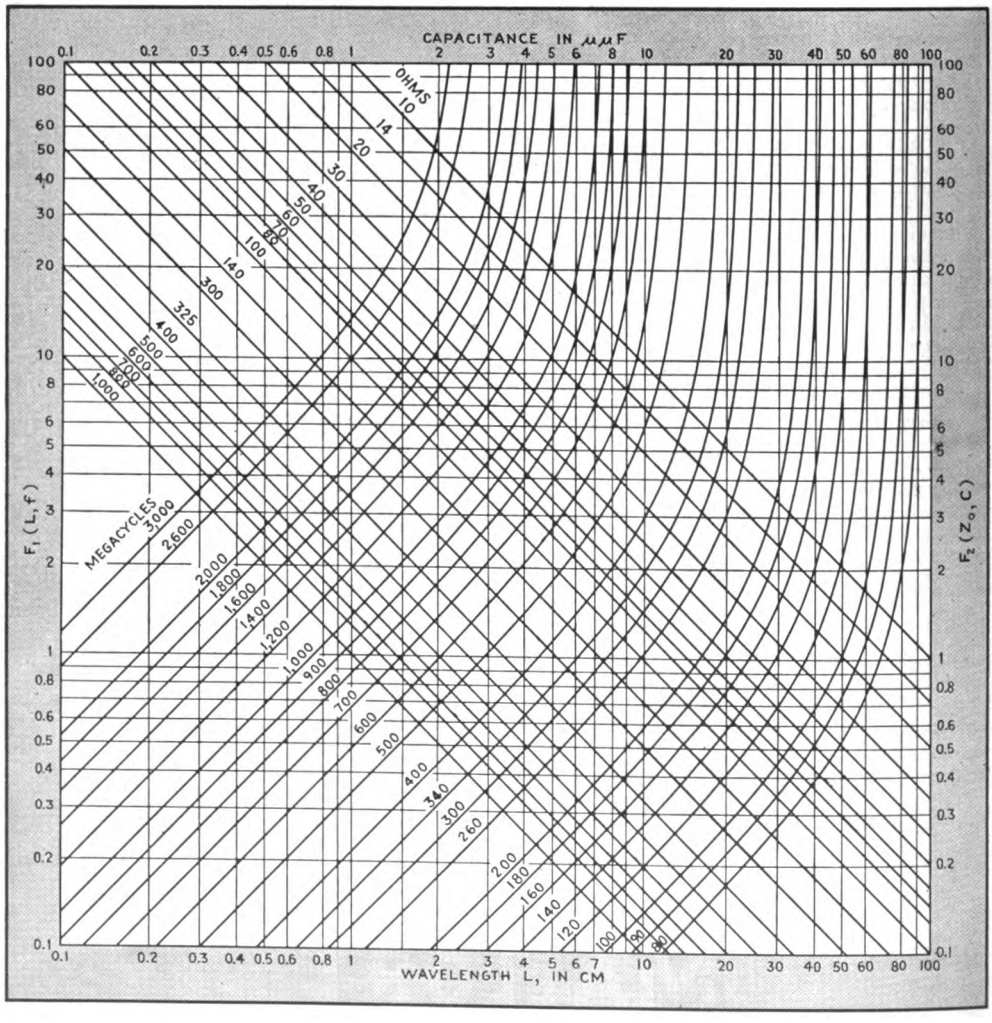
$$F_1(l, 150\ mc) = F_2(Z_0, 10\ \mu\mu f.) \quad (4a)$$
$$F_1(l, 200\ mc) = F_2(Z_0, 5\ \mu\mu f.) \quad (4b)$$

Using the graph, make a table of solutions of Eq. 4a, alone, and another of solutions of Eq. 4b, alone.

l in cm	Z_0 in ohms from Eq. 4a	Z_0 in ohms from Eq. 4b
10	325	360
15	207	220
20	147	143
25	108	94

Draw the curves corresponding to both tables on the same graph, using identical scales for both as in Fig. 2. The intersection of the two curves gives the solution; in the present case: $Z_0 = 164$ ohms, $l = 18.4$ cm.

As a purely mathematical problem, the contours of the graph may be used over the entire ranges of f and Z_0 for the solution of Eq. 3, but the application of such solutions to actual physical circuits is of doubtful validity in the upper ranges of frequency and impedance. At high frequencies a shorting bar on a very high impedance line of less than a quarter wave length must itself form a considerable part of the line. Moreover, the assumption that the total capacitance involved can be lumped into a single element is undoubtedly invalid under these conditions.



Graphical solution of Eq. 1 for obtaining the value of one quantity when values of three are known or values of two quantities when the other two are known

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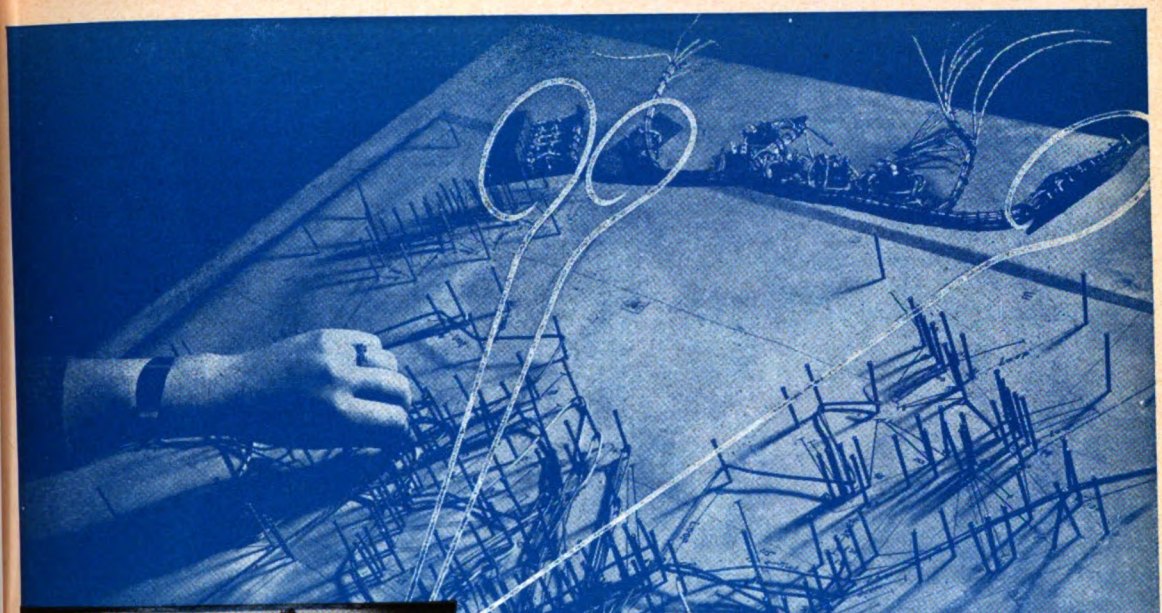

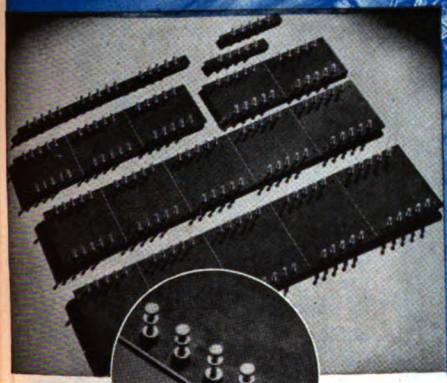

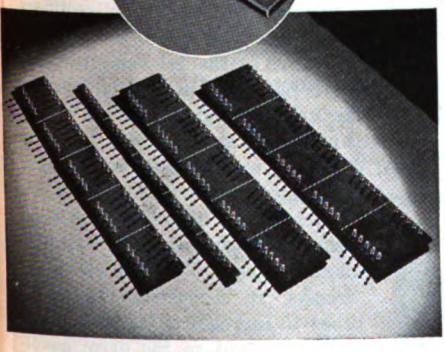

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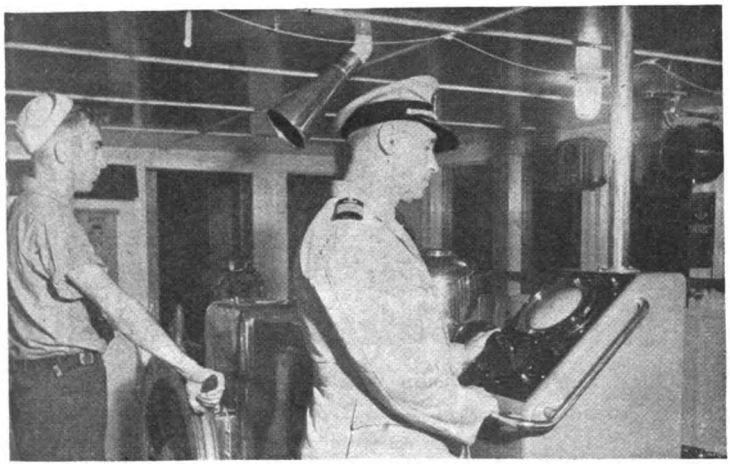
INDUSTRIAL CONTROL

Radar Navigator for Commercial Shipping 154
Balancing Operation Speeded by Motor Control 154
Precision Gaging by Blind Workers 156
Measuring Temperature of Molten Steel 164
A Phototube Amplifier 168
Timing Action of the Blocking Oscillator 184
Improved Socket-Punch Wrenches 204
New Photocell for Ultraviolet 212

Radar Navigator for Commercial Shipping

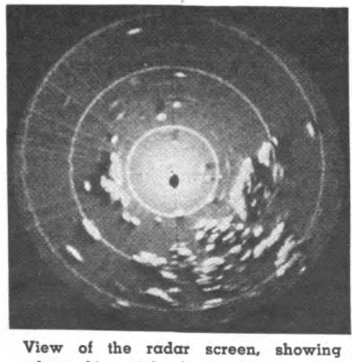
FIRST REPORTED SALE of radar equipment for peacetime industry has been made by General Electric Company who will supply five radar units ordered by the U. S. Maritime Commission for installation in merchants ships now being built. For navigation through fog and darkness, it enables the navigator to locate shore lines, land masses, other ships, buoys and other obstacles from 200 yards away up to 30 miles distant.



In the wheelhouse of the American Mariner, Captain Joseph Masse studies the screen of the cathode-ray tube in the General Electric radar navigator for commercial shipping. On the Great Lakes alone, more than 4,000,000 gross tons of cargo space were lost in 1943 because of the hazards of navigation through fog

One installation of the electronic navigator has been operating on the U. S. Maritime Service training ship American Mariner and used in navigating the waters of Long Island Sound. A few minutes of instruction have been found sufficient for beginners to grasp the fundamentals of operation and with a few hours of practice they learn safe recognition of various types of objects as well as their bearing with respect to the course and position of the ship.

A control console in the wheelhouse contains a cathode-ray tube indicator of the PPI type. Concentric rings indicate the range with the ship's position being in the center of the scope. A range switch permits changing the scale of the field to cover a 2,6, or 30-mile radius. This permits the navigator to use the 30-mile range until the ship approaches to within six miles of the obstacle, then switching to the chart whose radius is six miles. Further localizing can be made with the 2-mile range and objects can be observed down to about 200 yards on this scale. High shore lines are discernible at 30 miles distance, low shore lines at 10 to 15 miles, ships at 3 to 8 miles, and buoys at 1 to 3 miles.



View of the radar screen, showing other ships, islands, and other obstacles to navigation

A parabolic antenna is located on the top deck of the ship to transmit and receive the radar pulses. This rotates at a speed of 110 rpm and weighs 250 pounds. As in military radar, reflected waves from obstacles in the surrounding waters return to the rotating antenna during the time intervals between the outgoing pulses.

Balancing Operation Speeded by Motor Control

REDUCTION OF TIME in balancing submarine electric motor armatures from twenty man-hours to five man-hours is accomplished by use of General Electric Thy-mo-trol in controlling the speed of a balancing machine at Mare Island, Cal.

The illustration on the next page shows the control cabinet which contains two electronic rectifiers that supply voltage to the field and armature of the balancing machine drive motor. The control tubes in the cabinet regulate the output of thyratrons and permit throttling down to almost zero speed or smooth adjustment up to maximum speed.

Preselection of speeds is made by means of a potentiometer which is manually set. Through electronic circuits, it causes the thyratron tubes to increase or decrease their voltage output to the drive motor armature or field.

The cycle time is that elapsed from the time the stop button is pushed, weights adjusted, and the motor started again to the point where critical speed is attained. The Thy-mo-trol cycle is only thirty-seven seconds, compared to the two to four minutes required for a free-wheeling stop.

Such electronic control equipment is today practically a package

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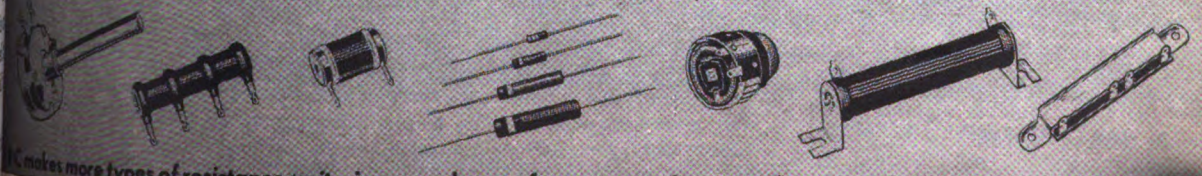

IRC makes more types of resistance units, in more shapes, for more applications than any other manufacturer in the world

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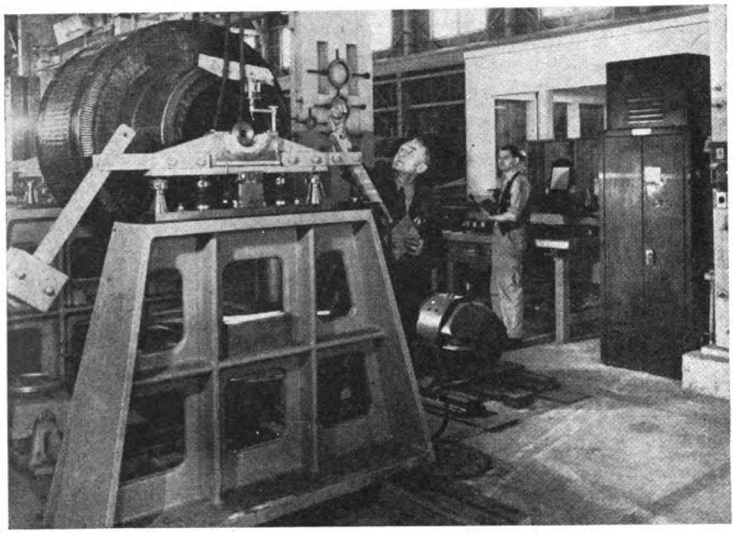


Complete setup of equipment for balancing submarine electric motor armatures. Free to revolve in the frame, the armature is rotated by the drive motor on the floor. Controlled acceleration and deceleration is accomplished by a General Electric Thy-mo-trol unit in the cabinet at the right

unit. It includes the d-c motor, the control panel, control station and the transformer. It is easy to install and has been applied to many other machinery applications such as, lathes, drill presses, millers, and similar equipment, and in the operation of many testing machines.

Precision Gaging by Blind Workers

THOUSANDS OF BLIND PERSONS who seek jobs in industry were given new hope by a recent demonstration of a precision production gage in the Canton factory of Timken Roller Bearing Company. A blind operator using the instrument checked the outer races of bearings in an outside diameter gage at a rate that compares favorably with that of an operator having normal sight. Indication of oversize, undersize, and normal readings are provided by an a-f oscillator that produces three different tones from a loudspeaker mounted on the back of the workman's chair.

The diameters of the components of Timken bearings are ground within very close limits of their specified sizes and checked on precision gages with electrical or mechanical dial-type indicators. These show amplified readings of variations in the diameter of the work piece under test.

For blind operators, the a-f oscillator provides audible signals. An article that is within the size limit produces a tone of one frequency and the article is passed as meeting the standard. If the speaker produces a tone of a higher frequency, the article under test is oversize, while a lower tone is produced by an undersize part. Either of these tones causes the operator to reject the unit.

Oscillator Circuit

The three audio frequencies are produced by the circuit shown in Fig. 1. This electronic oscillator is controlled by relays connected to the three indicator lights of an electronic gaging system. The red, green and orange panel lamps correspond to the three frequencies of the oscillator. The red lamp

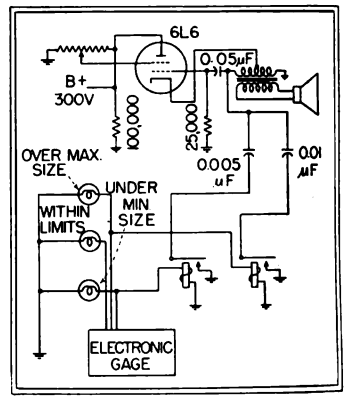
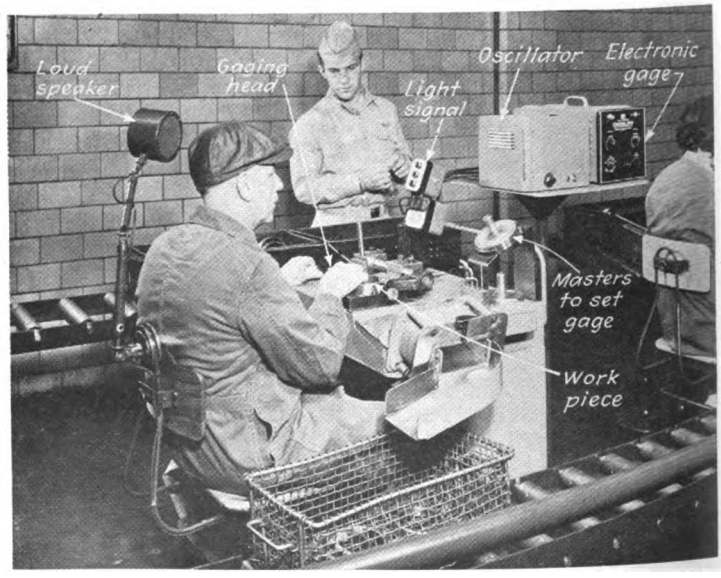


Fig. 1—Circuit of the audio oscillator used by Timken to provide audible gage indications to blind workers



The outside diameter of roller bearing cups are gaged by Sylvester Pfendler, blind Timken employee. Audible indication of over, under, and normal size is provided him by an a-f oscillator that feeds the loudspeaker. Manufacturing details of the device will be released without charge to any interested manufacturer

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30 70	White	183 C	257 C
20 80	Purple	183 C	276 C

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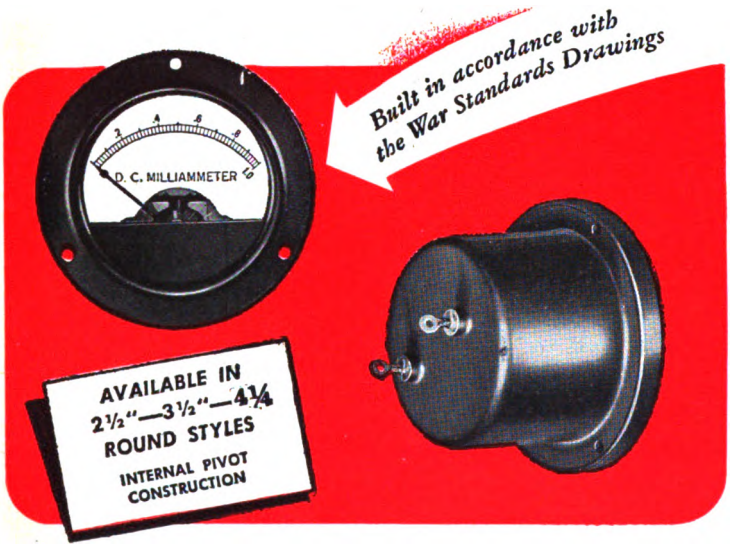

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In developing the present model, almost two years of experimental work with various gages was spent before Timken engineers were satisfied. They first developed a Braille gage in which the article to be gaged was pushed between two points (representing the proper diameter) in a horizontal plane electrically connected to a

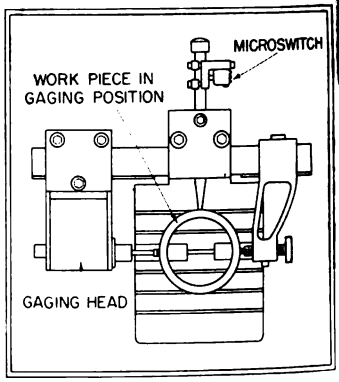

Fig. 2—Mechanical diagram of the work table and gage head on which bearing races and other parts are gaged by blind workers

finger block. The contact of the article raised the first, second, or third of three points on a vertical plane. This was considered too cumbersome for wide application.

Radio Range Signals

An electronic gage was suggested by a Timken official whose flying experience had made him familiar with the A and N on-course signals. An earphone reproduced the letter A if the article was too small and if too large, the letter N. If the article was acceptable, the signals joined to produce a continuous tone. Minute high and low spots in the surface of the article interfered with the transmission of the signals and this

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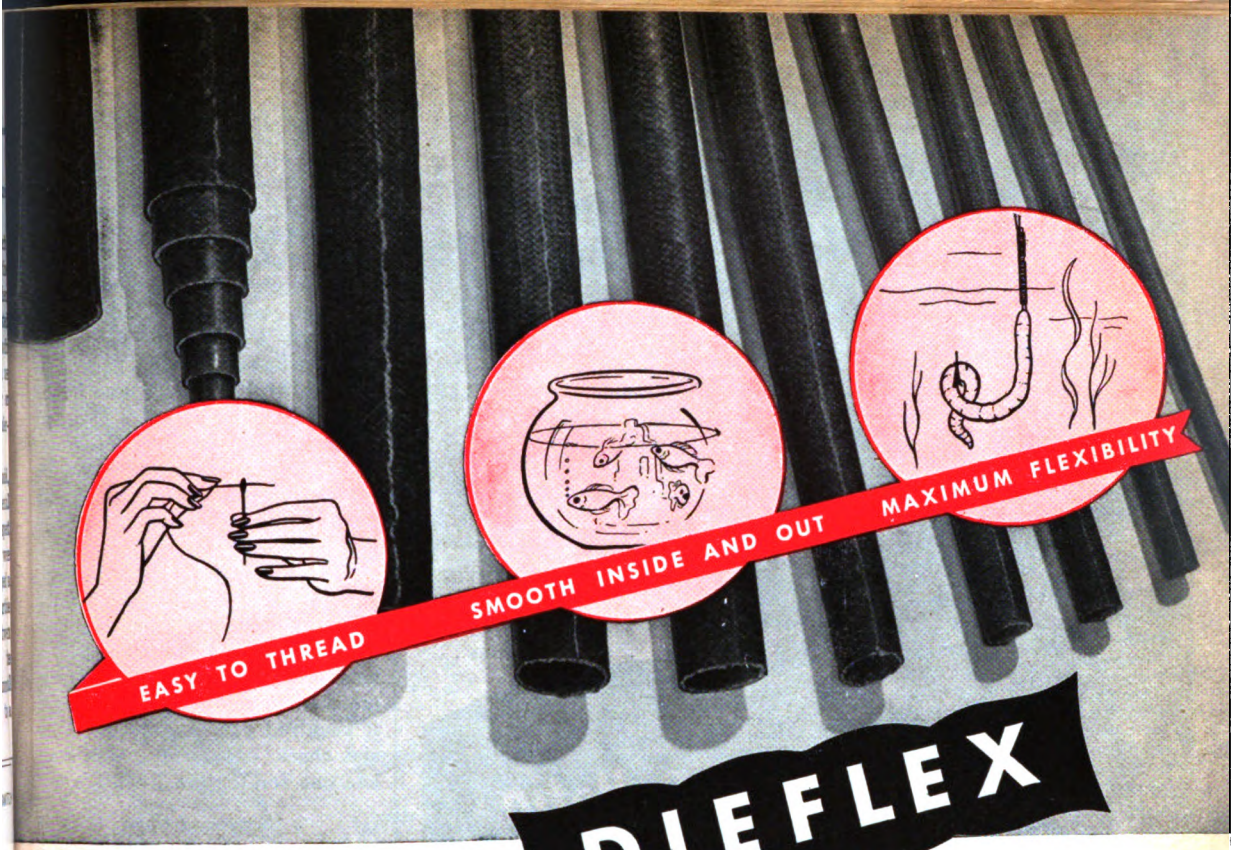

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This New Bulletin tells you what you want to know about

ACCURATE FIXED WIRE WOUND RESISTORS

DIMENSIONAL SPECIFICATIONS • MOUNTING AND TERMINAL DESIGNS • POWER DISSIPATION • TEMPERATURE COEFFICIENT OF RESISTANCE • MAXIMUM RESISTANCE CHARTS • RESISTANCE ALLOYS • MOISTURE AND FUNGUS PROOFING • HERMETIC SEALING

Shallcross Types Designed to Meet JAN-R 93 Specifications

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indicating gage was abandoned.

Another electronic unit was tried that produced a high, low, or normal audio tone in the earphones. To overcome fatigue due to the constant sound, a photoelectric unit was installed. This used a beam of light across the gage head so that when no work was in the gage the sound ceased. This was discarded after the operator objected because the earphones deprived him of any outside sound, making him feel closed-in and helpless.

This led to the use of a loud speaker fixed on the back of the operator's chair. Then the foreman, who sets up the gage with a master and checks it for accuracy, objected to the new model because it required two masters to set up and check, one for the high limit and one for the low limit.

Simplified Gage

A visual gage was then added to the sound one, eliminating the need for two masters. Since the device was becoming complicated, the phototube was eliminated by adding a switch to the back-stop of the gage to shut off the tone when the gage was not in operation. This final model proved satisfactory to the operator and the foreman and is the one now in operation.

Helen Keller, flanked by Pat Thomson, her constant companion for more than thirty years, attended the demonstration with high-ranking leaders of the blind, of industry, the American Legion and officers of the company.

• • •

Measuring Temperature of Molten Steel

THE TEMPERATURE of molten steel covered with slag is measured within 45 seconds by a new platinum thermocouple when used in conjunction with an electronic recorder. Use of the device is expected to improve the quality and uniformity of stainless steel.

The thermocouple has an immersion head comprising a platinum and platinum-rhodium thermocouple encased in a fused silica tube

Motors, Gen
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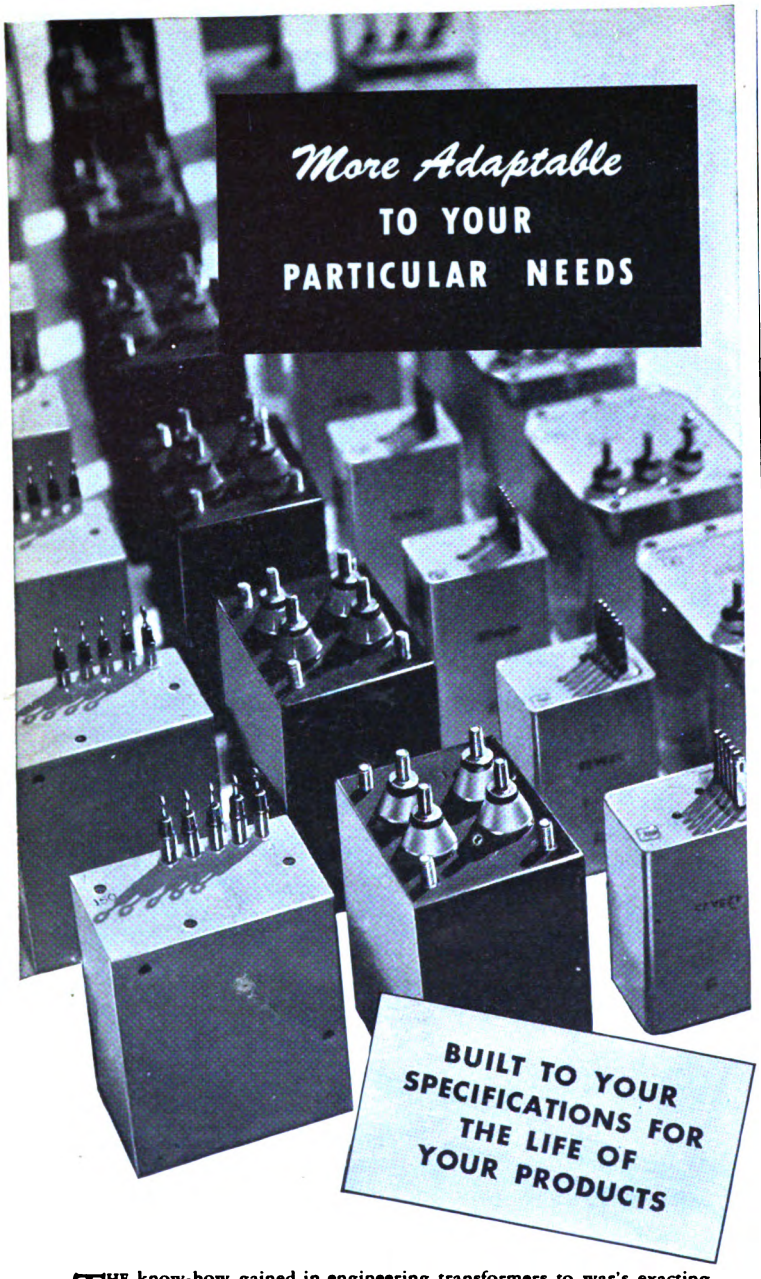

THE know-how gained in engineering transformers to war's exacting specifications is now available to solve your peacetime transformer needs. Stancor engineers are ready to study and master the toughest problems you can set them. Production men trained to exacting standards, with modern equipment and precision winding machinery, assure that highest specifications will be met in the finished product.

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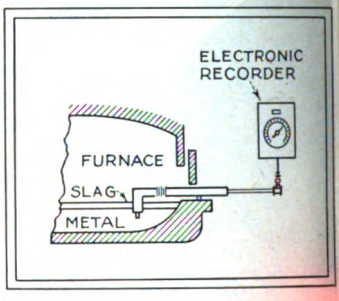
mounted in a block of graphite at the end of a 12-foot insulated pipe.

As shown in the drawing, the immersion head is manipulated through the furnace door and dipped into the steel bath. The exposed tip of the silica tube, containing platinum thermocouple wires, is immersed in the steel itself. A



Arrangement of thermocouple and Brown electronic recorder for measuring temperature of steel in furnace

graphite block protects the sensitive silica tube against deterioration by slag or mechanical shock.

Temperature is recorded automatically on a Brown ElectroniK recorder designed expressly for this application. The chart rotates at the rate of one revolution in four minutes and only during reading.

Patent rights to the platinum thermocouple have been acquired by Brown Instrument Company from Rustless Iron and Steel Corporation, whose engineers developed the unit.

• • •

A Phototube Amplifier

By Lt. John F. Scully

Point Lookout, New York

AN AMPLIFIER is often desired which, when used with a phototube, can be used as a switch to control a variety of industrial equipment. A number of such devices have been described in the literature, some of them more complex than might be desirable.

The amplifier to be described contains no coupling capacitors between stages and therefore only the inertia of the relay limits the speed of operation. In addition, it is positive in its action, being unaffected by normal power supply changes

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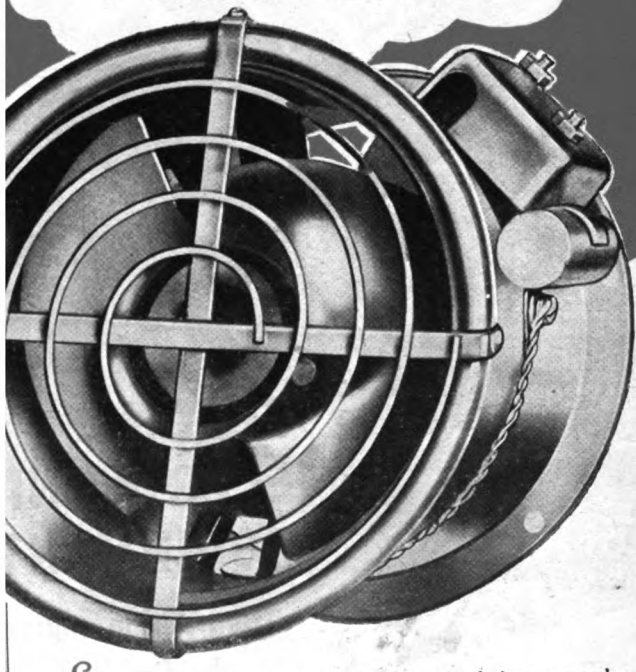

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All units available for shaft or belt drive. Adaptations can be made to precise requirements. Prototypes for postwar development projects are available. *Consult us about your Blower needs.*

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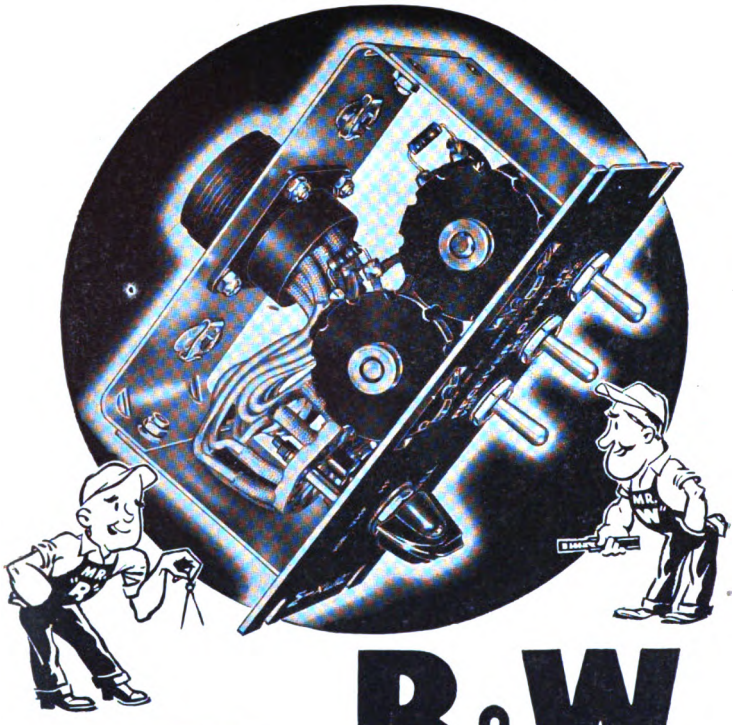

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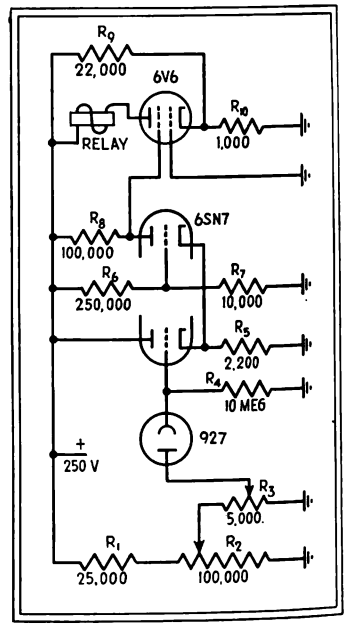
and parameter changes over a wide range. The circuit, shown in the diagram, contains a 927 phototube for the input excitation, a 6SN7 as a cathode follower working into a control amplifier, and a 6V6 power amplifier feeding the relay.

Circuit Operation

The unit operates as follows: First, assume the phototube to be removed from the circuit. Under this condition, the grid of the first 6SN7 section (the cathode follower) is at ground potential. Plate current of both sections of the 6SN7 flows through the 2200-ohm cathode resistor, so that the cathode follower is biased almost to cutoff.

The second section (control amplifier) of the 6SN7 has a positive 9 volts on the control grid, so that it conducts sufficiently for the plate voltage to drop to about 50 volts. The combined plate currents furnish a positive voltage of about 10 volts on the two cathodes. The plate of the control amplifier is connected to the power-amplifier screen which then has a potential of 50 volts. The grid of the 6V6 is grounded, and



Circuit of novel phototube amplifier which eliminates the time constant of coupling capacitors by driving the screen rather than the control grid of the output tube

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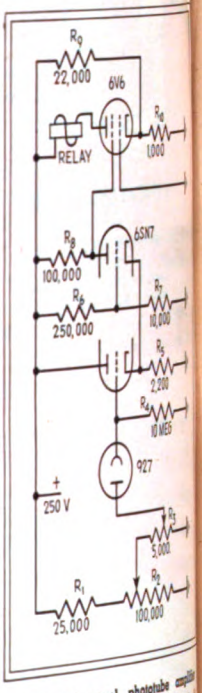

Circuit of novel phototube amplifier which eliminates the time constant of coupling capacitors by driving the screen rather than the control grid of the output tube

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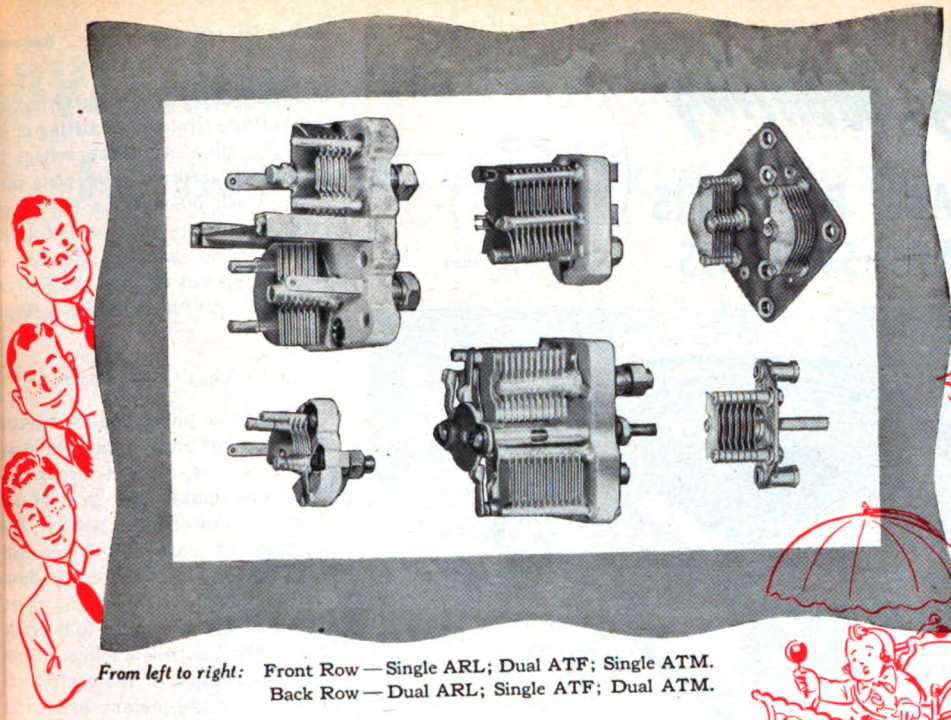
9 volts on the control grid, so that
it conducts sufficiently for the plate
voltage to drop to about 50 volts.
The combined plate currents furnish a positive voltage of about
volts on the two cathodes. The plate
of the control amplifier is connected
to the power-amplifier screen which
then has a potential of 60 volts. The
grid of the 6V6 is grounded, so



From left to right: Front Row — Single ARL; Dual ATF; Single ATM.
Back Row — Dual ARL; Single ATF; Dual ATM.

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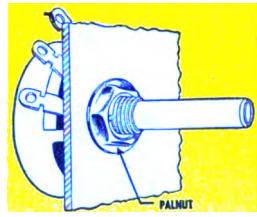

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Self-Locking PALNUTS

bias for the stage is furnished by the voltage divider consisting of R_1 and R_{2a}, plus whatever voltage is developed across R_{1a} by plate current. With 50 volts on the screen grid, 250 on the plate, and about 10 volts on the cathode, the tube is very nearly cut off, and the relay in the plate circuit remains unenergized.

Conditions With Phototube

When the phototube is inserted in the circuit and illuminated by an outside source, current through the phototube makes the grid of the cathode follower more positive. The increase of cathode-follower current results in a higher cathode voltage of 22 volts for the stage. This rise also is applied to the cathode of the control amplifier. Since the grid voltage of the control amplifier is held constant by divider R_6 and R_7 at 9 volts, the result is that close to cutoff bias is applied to this section. Actually, the tube would be cut off with the exact values given. However, the meter used in making the measurements was not sensitive, hence the voltages given are not exactly those which would be read with a vacuum-tube voltmeter.

Screen Control

The result of the drop in plate current is to raise the plate voltage, and hence the screen voltage of the power amplifier, to 170 volts. This increased screen voltage permits the 6V6 to conduct heavily enough to close the relay in the plate circuit. This relay then serves to control whatever device may be used with the amplifier.

The actual voltages for the nonoperative condition are between those given in the two cases above, since under normal conditions the phototube conducts to some extent, although not enough to operate the relay.

If desired, the device can be kept normally energized by a light source on the phototube, in which case any interruption of the beam would deenergize the relay and operate the controlled device.

Resistors R_2 and R_3 are the coarse and fine sensitivity controls, respectively. One control may be

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NOTE: *Amalgamated Engineers will gladly consult with you on the design and development of Plugs and Jacks for special applications—present or postwar.*

PLUG PL-55 and N.A.F. 1136-1

Long sleeve, two-conductor plug, mate to Jack JK-34-A. Withstands minimum of 60 cycles AC, potential of 500 volts effective, applied between any two terminals for not less than two seconds. Meets minimum insulation value of 2000 megohms between conductors at 68°F at humidities up to 100%.

PLUG, STYLE "A"

Two-conductor, special type plug for use with Neoprene or Buna S molded cords. Same specifications as PL-55.

PLUG, STYLE "D"

Two-Conductor, special type plug for use with Neoprene or Buna S molded cords. Same specifications as PL-55.

PLUG PL-204

Hand set. A special plug wherein both a modified plugs, PL-55 and PL-68, are held in place by a phenolic case. Same specifications as PL-55 and PL-68.

JACK JK-26, N.A.F. 215284-2

Two-conductor Jack, mate to PL-54. Tropicalized. Withstands 60 cycle AC potential of 500 volts effective, applied between any two terminals for not less than two seconds. Meets minimum insulation value of 2000 megohms between conductors at 68°F, at humidities up to 100%.

JACK JK-48

Light duty, two-conductor Jack, mate to Plug PL-291 and Plug 291-A.

PLUG PL-54, PL-540, PL-354, N.A.F. 215285-2

Short sleeve, two-conductor plug, mate to Jack JK-26. Same specifications as PL-55.

AMALGAMATED RADIO TELEVISION CORP.

476 BROADWAY • NEW YORK 13, N. Y.

used, but if both are used adjustment of the amplifier is simplified. If the plate of the phototube is connected to the arm of R_2 and R_1 is not used, R_1 should be replaced by a 750,000-ohm resistor.

Adjustments

Maintain moderate tension on the relay spring, with as small a travel distance as necessary to prevent sparking being maintained when the contacts are opened. A suppressor capacitor should be used across the relay contacts. Adjust R_1 to the maximum sensitivity position (all 5,000 ohms in the circuit). Adjust R_2 to the maximum sensitivity position. If the relay is properly adjusted, it will now operate regardless of the light on the phototube. If it does not, change the spring adjustment or the contact gap.

With the phototube under excitation from the light source with which it will be used, back off R_1 until the relay is deenergized. Rotate R_2 about one-eighth of a turn in the reverse direction. The relay will again be energized. Rotate R_1 until the relay is deenergized, and reverse the adjustment just past the point at which the relay energizes again. This last step completes the adjustment. Cutting off the light

• • •

GURKHAS HANDIE-TALKIE

Gurkhas of an Indian division in Italy used British radio equipment. Above, Havildar Birbahadur Limbu, Gurkha wireless operator on patrol is clad in white to blend with the snow. Gurkhas were members of an Indian division that held a section of the Italian front

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Gurkhas of an Indian division
used British radio equipment.
Havildar Birbahadur Limbu,
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were members of an Indian
that held a section of the

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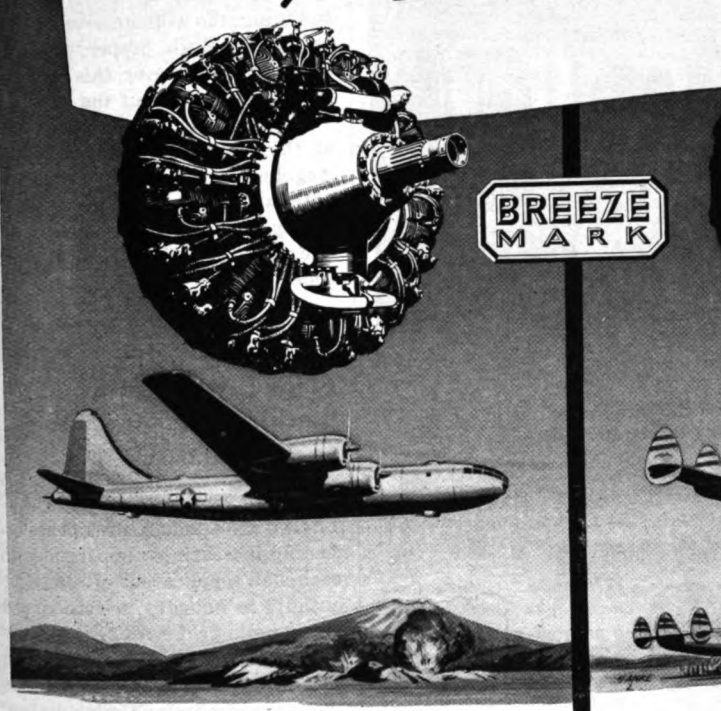

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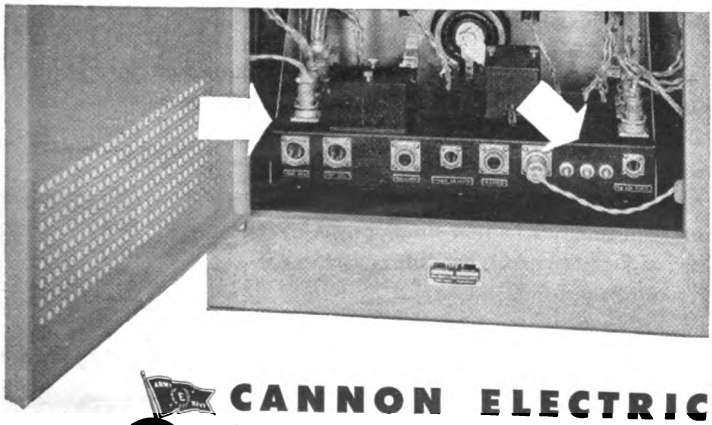
This is the Waugh Metal Analyzer (above and below). It gives an instantaneous indication of the hardness, grain structure and other properties of ferrous materials on which it is used. It performs this scientific feat by means of magnetic analysis and employs many precise electric circuits in its hook-up. These circuits are connected and test units are plugged in through various Cannon Connectors—indicated in the rear view of the open cabinet. Both plug and receptacle types are shown.

Wherever you need a quick, positive and secure connection in the electric circuits of the instruments you use or the products you manufacture, use Cannon Connectors. There are thousands of stock styles and sizes to choose from and a staff of experienced engineers to develop special Cannon Connectors for your use if need be.

A Type "K" Cannon Connector with integral clamp is pictured at left. Write for a Type "K" Cannon Catalog to get a general introduction to this Cannon line. Address Department A-120, Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.



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source will deenergize the relay, applying it will give positive closing of the relay.

Precautions

It is recommended that the leads to the phototube be shielded, as the cathode follower acts as a rectifier in the presence of 60-cycle pickup, changing the voltage levels in the amplifier. With proper placement of the leads, however, this causes no trouble even without the shielding.

No bypass capacitor can be used at the input grid because the 10-megohm resistor in conjunction with a sufficiently large capacitor to bypass 60 cycles would cause intolerable delay in circuit reaction time.

• • •

Timing Action of the Blocking Oscillator

BY EMANUEL LAST
Development Engineer
Munston Mfg. and Service Co.

TIMING AND TRIGGER circuits are becoming increasingly important with each new application of electronic circuits in industry, television, and allied radio fields. All types of multivibrators, start-stop circuits, and relaxation oscillators have made their appearance as timing devices. One of the lesser known but very useful timing methods is the blocking oscillator.

Operation of Circuit

A typical blocking oscillator circuit is shown in Fig. 1. The transformer shown has a one-to-one turns ratio. Since there is no external or fixed biasing arrangement in this circuit, the tube will conduct

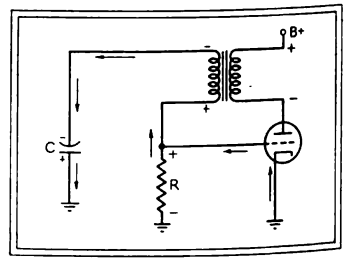

FIG. 1—Circuit of typical blocking oscillator and polarities established when switch is first closed

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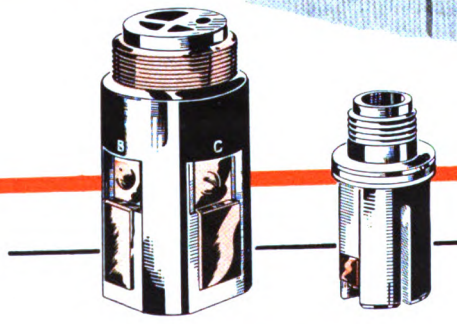

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with the closing of the switch. When the tube current begins to build up through the plate coil of the transformer, there will be a back emf across the coil, of polarity as shown in Fig. 1, which results in a dropping of plate voltage.

The changing primary current will induce a voltage into the secondary or grid coil of opposite polarity to the voltage in the plate coil. This induced voltage will cause an electron flow in the grid circuit, producing a voltage across resistor R of such polarity as to make the grid positive with respect to the cathode. At the same time, the grid current will be charging capacitor C through resistor R until the grid goes positive, when the charging current will flow mainly through the tube from cathode to grid. The charging path being through the cathode-to-grid resistance, which

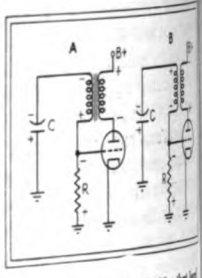

FIG. 2—Changes in polarities that lead to cutoff of plate current

relatively small, the capacitor will tend to charge quickly to the voltage induced into the grid coil.

The grid of the tube having been driven in a positive direction, the tube will draw more plate current. The increased plate current will produce a further drop in plate voltage and a greater induced voltage into the grid circuit, tending to drive the grid further positive. As this action continues we soon arrive at a point where the increase in grid voltage will not result in any increase in plate current as previously. Since the rate of change of plate current thus decreases, the voltage induced into the grid coil decreases.

Effect on Capacitor

The voltage across capacitor has been closely following the voltage induced into the grid circuit. Therefore, a reduction in the

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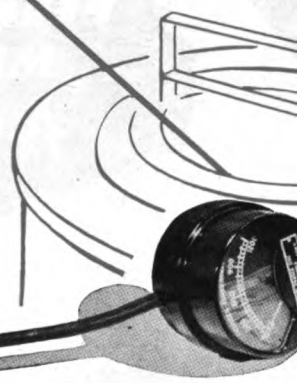

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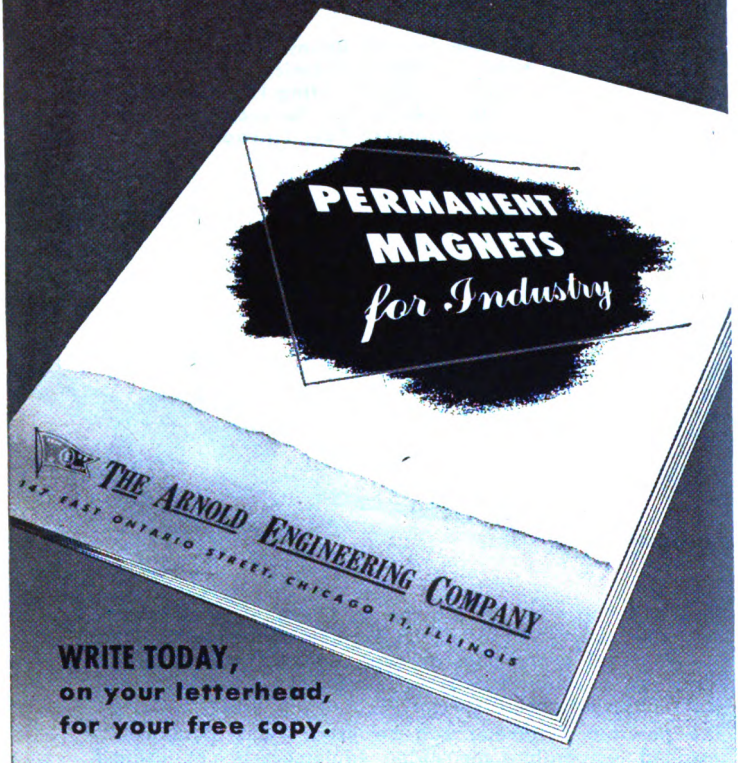

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duced voltage due to the rate of increase of plate will result in the voltage capacitor being slightly the induced voltage. The reversal of current flow in the circuit gives us a slight voltage on the grid (voltage the capacitor less the age as shown in Fig. 2A).

Condition for Cutoff

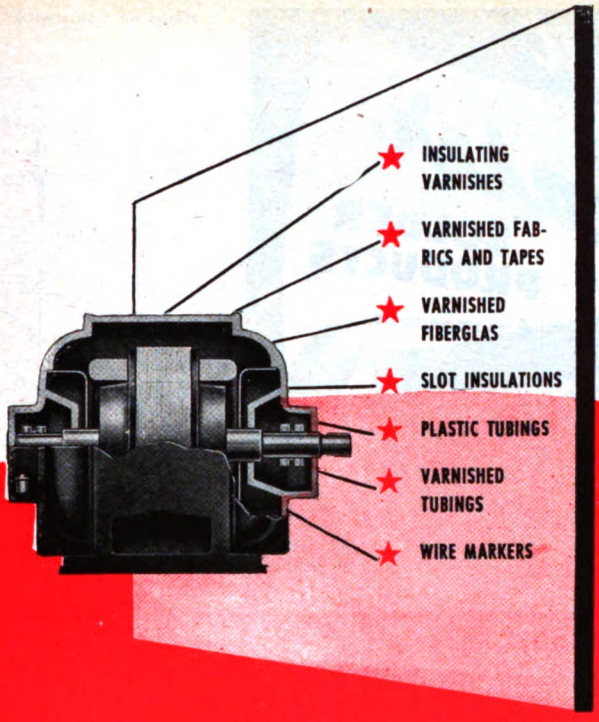
The grid voltage going negative would tend to tube draw less current. is a coil in the plate circuit, will build up a counter pose this change in current. grid coil will have a voltage into it 180 degrees out with the plate-coil voltage. the voltage across the capacitor the induced voltage are causing a current flow that large voltage across resistor Fig. 2B.) This voltage grid negative with respect cathode by a more than amount to cut off the tube.

The cutting off of plate will cause the plate voltage to to B + and then rise above value due to the back emf plate coil resulting in a slight lation whose extent will depend circuit constants.

The induced voltage in the circuit will be negligible after fast positive rise in plate The voltage on the grid will due only to the capacitor charging through resistor discharge will give an exponential decay of grid voltage continuing fall till the grid voltage reaches cutoff potential of the tube. As the grid voltage rises above off, the tube will conduct and the cycle will repeat itself. Fig. 3 shows the plate voltage grid voltage E_c, and the across the capacitor E_c for a of three cycles.

Output at Plate

The output of this circuit usually the platevoltage The negative pips or pulses each time the tube operates. the frequency of the pulse tion depends on the amount of the tube is cut off or the time



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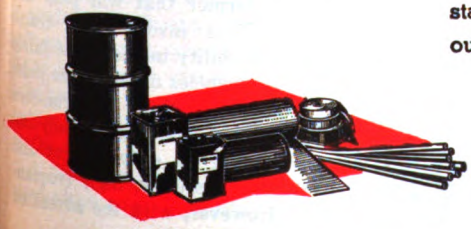

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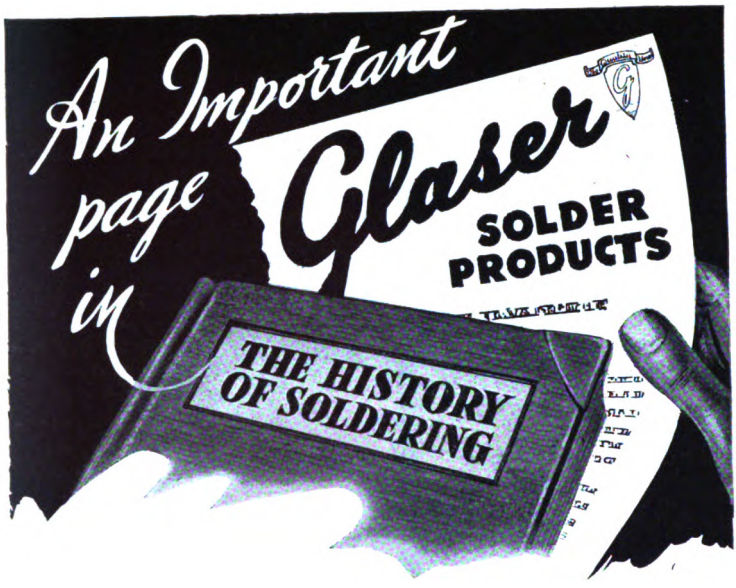

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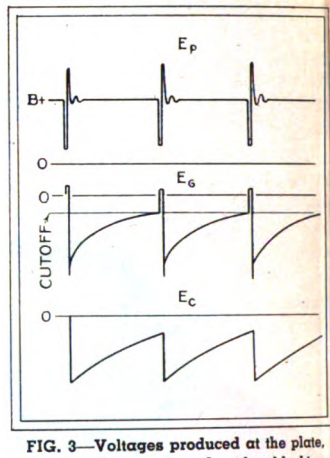

FIG. 3—Voltages produced at the plate, grid, and capacitor by the blocking action

charge of the capacitor in the grid circuit from its charged voltage to the cut-off voltage. This time will depend on three items; first, the voltage to which the capacitor is charged; second, the cut-off value of the tube; and third, the *RC* of the discharge circuit. The first two items will be determined by the applied voltage, the tube, and the transformer. Once these factors have been determined, the *RC* will be the main frequency controlling factor. Thus by varying the resistor and capacitor, we can considerably vary the frequency of the output pulses.

Shape of Pulse

In addition to controlling the frequency of the output voltage, we may also be interested in the output waveshape. The output waveshape can be considered under two aspects; first, the sharpness and time duration of the negative pulses; and second, the oscillation following the negative pulse.

The sharpness and time duration of the pulses will depend largely on the transformer used. For a sharp, short-duration pulse, we must have a transformer that will pass this pulse. This involves the transformer's ability to pass some fairly high frequencies of which the pulse is composed. With an iron-core transformer, this is practically impossible due to eddy current and hysteresis losses at high frequencies. However, with the advent of

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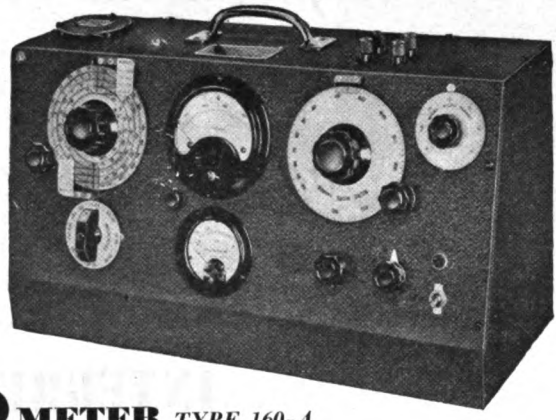

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Versatile Plastic Effects Manufacturing Economy

Probably no other field uses more plastics than electrical manufacturing. The myriad of electrical products on the market today call for thousands of versatile-propertied plastic parts. The majority of these parts are molded from phenolic compounds because the phenolics are the most versatile of all plastics.

Since its inception the plastics industry has been prone to stress volume when it comes to molded plastics applications. At times, applications where plastics fit the job better than any other material have been passed up because the number of parts required was so limited. However, there are many instances where the inherent physical properties of plastics so far outweigh higher costs due to small volume that the end result warrants the use of these materials. Such was the case with Budd Induction Heating, Inc., who use the heavy molded Durez parts illustrated in their induction heating machines, and who found that the molding of plastics was more practical and economical than machining.

Electrical Resistance Required

Induction heating machines employ high-power, high-frequency currents and naturally require a plastic material with excellent electrical properties for many of their vital parts. In addition, they require a material of high impact strength. In short—and like so many instances in electrical manufacturing—they require a material that is versatile. Therefore, the choice of a Durez phenolic compound for this purpose was a most logical one.

Molding Ingenuity

As molders of the large, heavy plastic terminal assembly illustrated, Michigan Molded Plastics, Inc., in collaboration with engineers of Budd Induction Heating, Inc., accomplished a feat which typifies the ingenuity of America's custom molders. They took a versatile, high-impact Durez phenolic molding compound with unusually excellent electrical properties and molded a 3-piece terminal assembly for an induction heating machine which not only replaced an original assembly consisting of five pieces but did it with tremendous savings in time and costly machining.

Versatile Phenolics

Too much can't be said about the versatility of phenolic plastics. Such properties as dielectric strength, diversity of finishes, excellent moldability, impact strength and highest dimensional stability at temperature extremes, as well as resistance to moisture, heat, mild acids and alkalies, are inherent characteristics in all of the more than 300 Durez phenolic molding compounds.

Perhaps you are looking for the plastic that fits your job. If so, you should make Durez your starting point. The services of experienced Durez technicians are available at all times for your benefit. Durez Plastics & Chemicals, Inc., 3210 Walck Road, North Tonawanda, New York.

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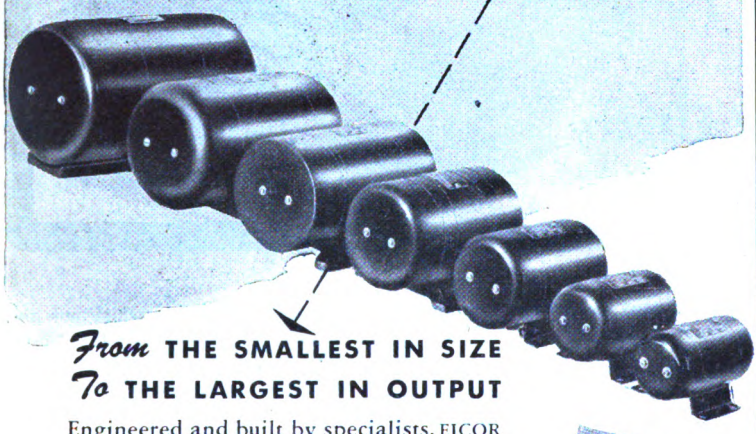

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4100	200	4 1/16 in.	6 1/2 to 7 3/8 in.	6 3/4 to 9 lbs.
4500	250	4 1/2 in.	6 1/2 to 8 in.	11 1/2 to 13 1/4 lbs.
5100	350	5 1/8 in.	8 1/2 to 10 in.	17 to 21 1/2 lbs.
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is acceptable and where too large a voltage is not required. This method is to insert an unbypassed cathode resistor and take the output across the cathode resistor. Using this method we obtain positive pulses which have no oscillating component. (See Fig. 4C.) A fourth possibility would be to take the original output and feed it into a limiter circuit that would respond only to the negative pulse.

• • •

Improved Socket-Punch Wrenches

By RONALD L. IVES
Dugway Proving Ground
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IN MODIFYING FINISHED chassis units of complicated electronic equipment, new socket holes were required. The requirement that the instruments be out of service for a minimum length of time imposed a number of tooling problems that are not ordinarily encountered.

Greenlee screw-type socket hole punches were chosen for the job and it was found that the traditional method of tightening the pressure screw on these punches was with a pair of pliers. This led

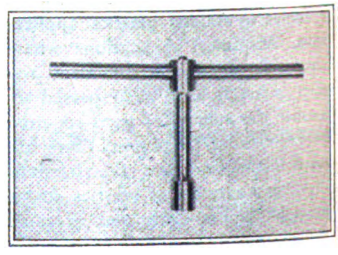

Fig. 1—Tool A consists of a T handle and a socket extension

to short tool life, considerable damage to adjacent equipment due to the pliers slipping off the screw head, and numerous hand injuries to personnel.

Use of a wrench greatly increased the life of the socket-punch screw head, but did not greatly decrease damage to equipment and hands due to wrench slippage.

New Tools

Use of a ¼-in. square ratchet box wrench, in locations where there was adequate hand clearance, led to a satisfactory reduction in the

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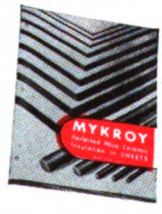

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number of tool replacements, breakages, and injuries.

Where the location of the new socket hole was in the center of a chassis so that adequate hand clearance was not provided, the punch was first turned with a ½-in. square socket extension fitted with a tap wrench. From this, tool A (Fig. 1) was developed. This tool consists of a ½-in. square socket extension brazed into a hole in a T handle.

By turning the square extension with a ½-in. square ratchet box

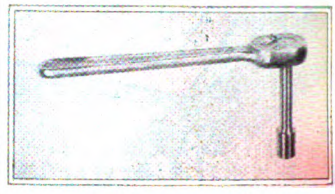

Fig. 2—Tool B, a ratchet wrench that fits a socket punch

wrench, a ratchet wrench for tightening punch screws in difficult locations developed. The final form of this is tool B (Fig. 2), consisting of a square extension fitted and brazed into a ratchet handle.

Speed Tool

On the basis of experience with the two tools described, tool C (Fig. 3), consisting of a square exten-

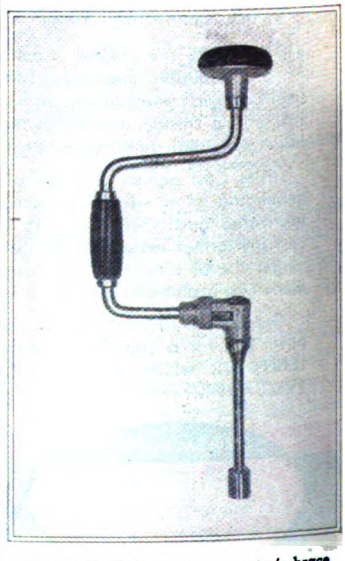

Fig. 3—Tool C uses a carpenter's brace for rapid production work

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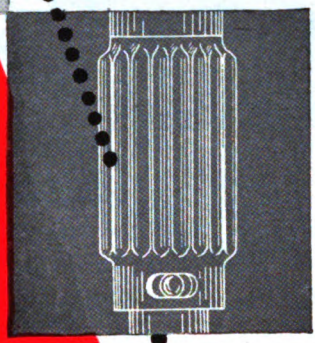

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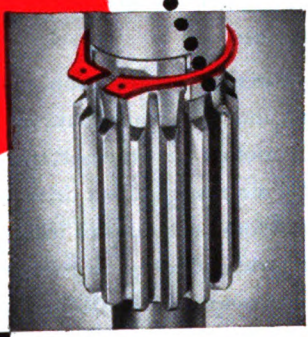

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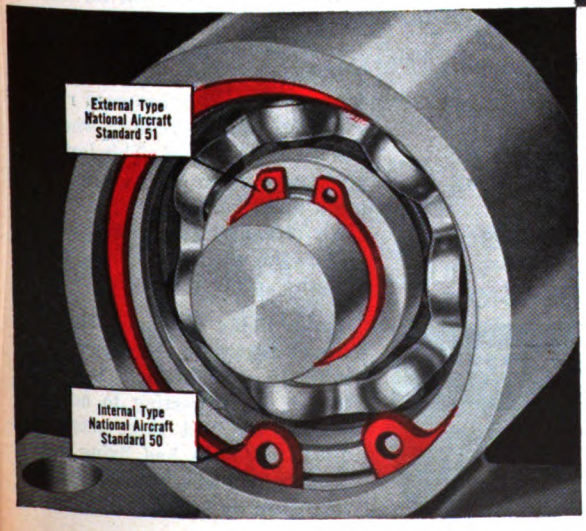

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By coupling various ½-in. square fittings to any of these tools, a socket hole can be made in almost any location where it is possible to drill a pilot hole for the punch screw.

Use of these tools led to an estimated 25-percent increase in production, with an accompanying decrease of equipment damage, and a virtual elimination of hand injuries.

New Photocell for Ultraviolet

THE BRITISH COMPANY Cinema-Television Ltd has produced a new photocell for ultraviolet light which is an improvement on the older sodium cell with a quartz window.

The envelope of the new tube is made entirely of fused quartz since the cathode is antimony caesium and there does not seem to be any cement known which can be used to make a vacuum-tight quartz window in a glass cell and yet which does not combine chemically with the caesium vapor used during the sensitising process.

The antimony-caesium cathode responds to wavelengths between 6,500 and 2,000 Angstroms with a peak between 4,000 and 4,600. In the ultraviolet region, the new cell is far superior to the older sodium type and produces from 100 to 500 times the output, size for size and operating in a vacuum.

What is equally or more important, is the fact that the antimony-caesium cathode has good response in the visible region, where the sodium cell is bad. This last defect often required two cells (of differing color response) when continuous measurements had to be made from the ultra violet to the red end of the spectrum.

Radio Relay Services. The latest figure for radio relay service subscribers in England is 551,703 and it is interesting to note that during the last three months of 1944, when we had flying bombs, rockets, and what you will, the total increased by 24,000.

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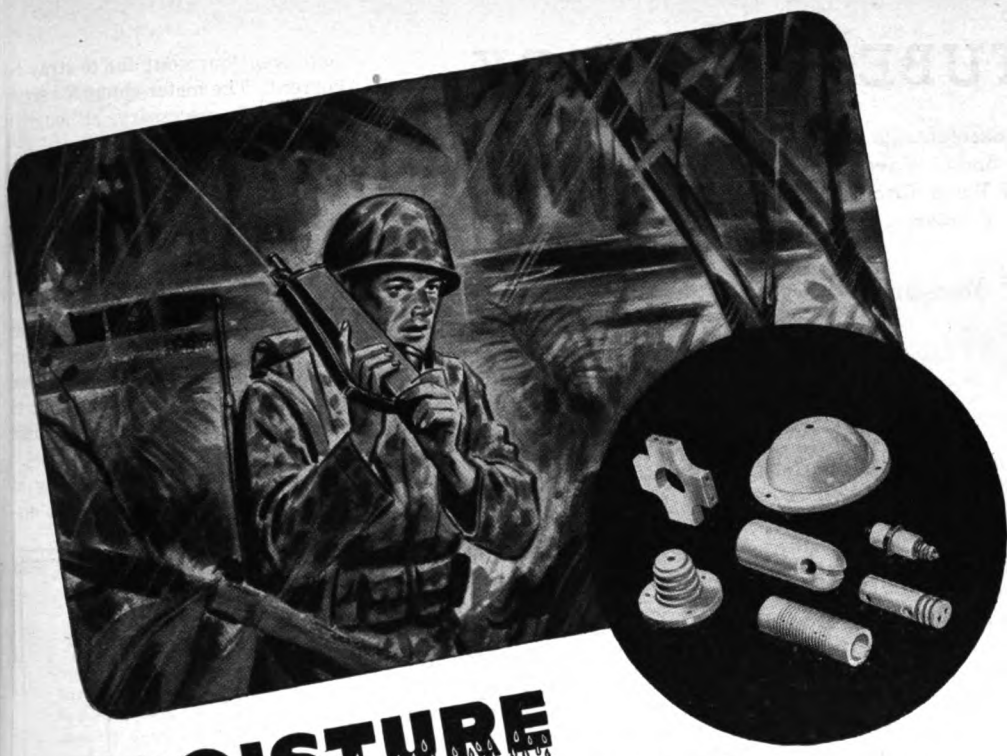

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TUBES AT WORK

Power Measurements at Very High Frequencies 216
Recorded Sound Waves Locate Bomb Hits 218
Stabilized Pulse Circuit 230
Post War Receivers 234

Power Measurements at Very High Frequencies

By WILLIAM MARON
Senior Radio Engineer
North American Philips Co.
Dobbs Ferry, New York

THIS PAPER DESCRIBES a means for measuring r-f power between 20 and 40 watts at 100 megacycles.

Figure 1 shows a single-ended class C amplifier stage, using long lines. The antenna coupling circuit, consisting of L_1 and C, is designed to match a 70-ohm coaxial line to feed the antenna. The load should, therefore, be in the vicinity of about 70 ohms. A 60-watt, 110-volt lamp operated below full wattage has a resistance of about 70 ohms; any slight discrepancy is compensated by the point of attachment to the coupling circuit.

If a photoelectric cell *PE* is placed in the path of light from the lamp, a direct current will be generated by the photocell which can be measured by a microammeter. The amount of current given by *PE* is dependent on the quantity of light produced by the lamp, which in turn is a function of the magnitude of r-f flowing through it. By calibrating the microammeter it is possible to find the amount of r-f power produced by the amplifier.

Construction Details

As some photoelectric cells are damaged if subject to temperatures above 120 F, it is advisable to separate the cell from the lamp by at least twelve inches. This is particularly important if measurements are to be made over an extended length of time.

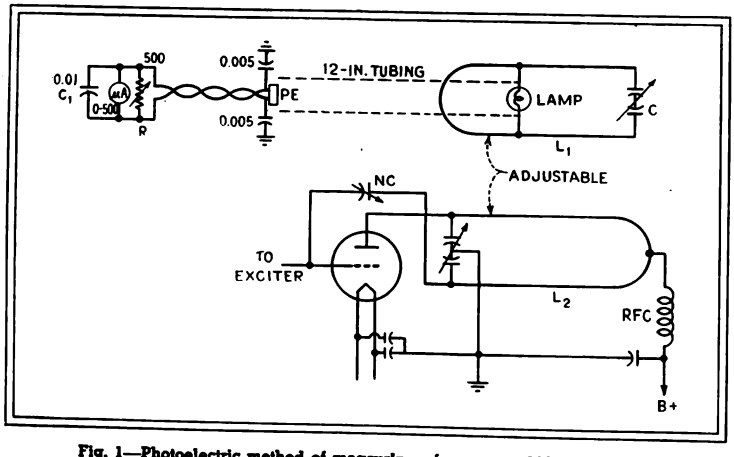

Fig. 1—Photoelectric method of measuring r-f power at 100 megacycles

A piece of Bakelite tubing with an inside diameter sufficient to accommodate the lamp is cut to proper length. A series of small holes is drilled in the tubing to provide ventilation. A hood over the holes prevents entrance of extraneous light. The photocell is mounted at the other end of the tubing and bypassed for r-f as shown in Fig. 1. The length of leads going to the microammeter is of no relative importance; the leads, preferably, should be shielded. Bypassing the meter is also desirable to prevent burn-out due to stray r-f current. The meter shunt R may or may not be necessary, although it is a precaution to include it.

The bulb is debased to cut down capacitance and the cement and insulation removed between the center contact and outside contact.

Calibration

Figure 2 illustrates a calibration circuit for lighting the lamp from the a-c line. The meters are used for computing the power input to the bulb; a wattmeter may be used if available.

To calibrate, remove one leg of the bulb from L_1 and, without disturbing the position of it in regard to the photocell, connect the low-frequency a-c. Adjust the voltage with the autotransformer and read the microammeter. Plot the wattage input to the lamp versus meter reading. Should the pointer go off

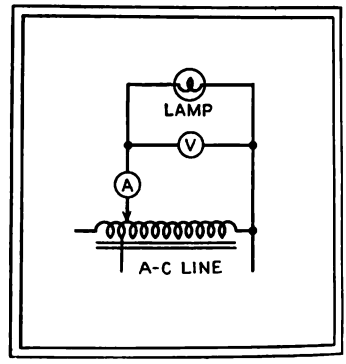

Fig. 2—Circuit for calibrating the lamp from an a-c line. If the lamp is replaced, recalibration is necessary

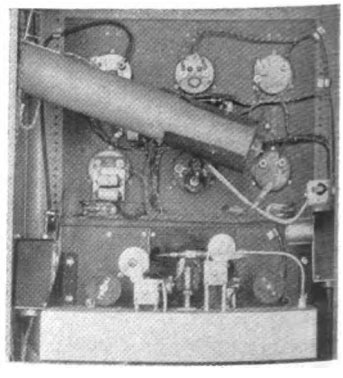

Fig. 3—A 100-mc transmitter with photoelectric equipment built in for measuring the power output

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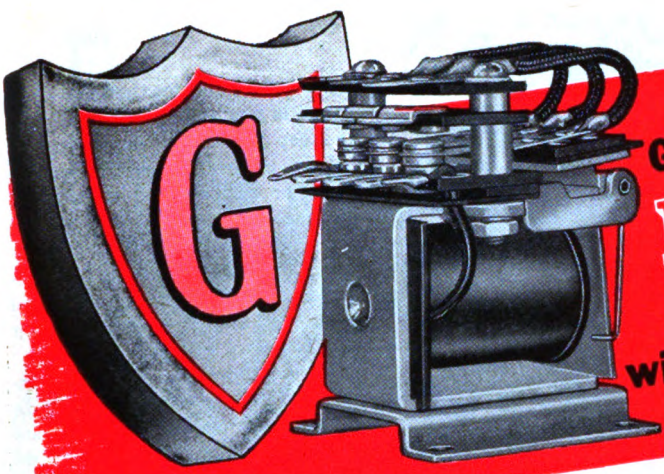

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The maximum switch capacity of the Standard Series 345 is three pole, double throw. Contacts are rated at 12½ amperes at 110 volts, 60 cycles, non-inductive A.C. Moving contacts are attached to but insulated from the armature by a bakelite plate. Terminals are solder lugs. Weight is 6½ ounces.

VARIATIONS OF THE SERIES 345 RELAY

TIME-DELAY

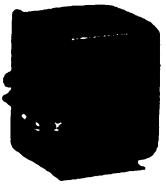
WINDING—Multi-wound coils are available for operation on two or more circuits. Or coil may be wound to operate on the discharge of a 3 mfd. condenser.

CONTACTS—Normal switch capacity is three pole, double throw; maximum switch capacity may be up to six pole double throw with 12½ amp. contacts, or any variation of contact combinations within this range, including the operation of contacts in sequence. The flexibility of the contact springs may be increased through the use of coil spring rivets.

TIME DELAY—On D.C. coils a time delay of 0.25 seconds on release or 0.06 second on attract may be achieved through the use of copper slugs which require these time intervals for saturation or de-energizing depending on whether they are used on the heel or head of the coil.

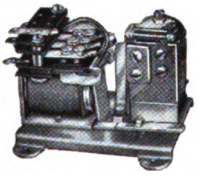
DUST COVER—For applications where this relay may be subject to injury or in atmosphere where dust may be present in sufficient quantity to impede operation, the SERIES 345 may be equipped with a metal dustproof cover.

SCREW TERMINALS—Screw type terminals are optional for applications where terminals must be disconnected occasionally or where solder lug terminals are not otherwise practical.



DUST COVER

INTERLOCKING: Here the series 340 a-c relay is coupled with the d-c coil of a series 405 short telephone type relay in an overload application. Under normal conditions the series 340 contacts are mechanically held in a closed position. Normal current flows through the series 405 coil and then through the series 340 contacts to the circuit for which overload protection is desired. Excessive current, however, energizes the series 405 coil, releasing the locking arrangement and breaking the series 340 contacts. Push button control resets to normal but is ineffective if current is still excessive.



INTERLOCKING UNIT

SERIES 345 RELAY DATA

Normal Volts	Minimum Volts	Normal M.A.	Minimum M.A.	Coil Resist.	Normal Wattage
6	4.8	600	480	10	3.56
12	9.8	300	245	40	3.56
24	18	148	111	162	3.56
32	25.6	112	89	287	3.56
115	92	31	25	3720	3.56

Minimum operating wattage.....2.3

If you will write us about your relay problems our engineers will be glad to make recommendations which may save you time and money. Should you desire a quotation, please mention quantity.

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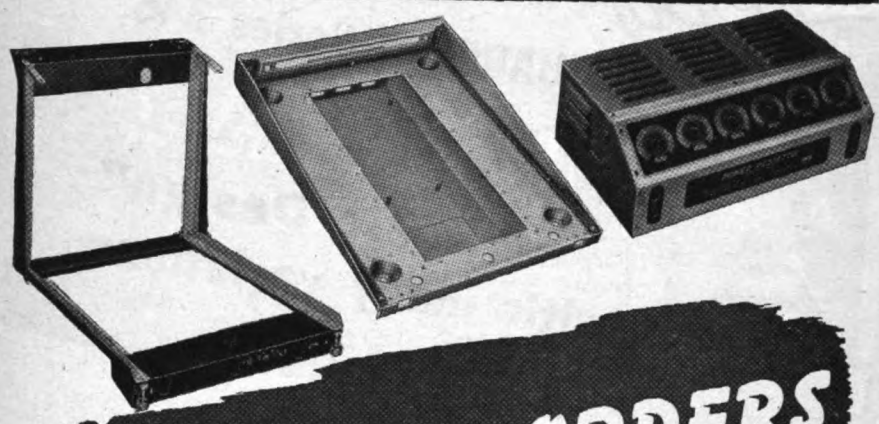

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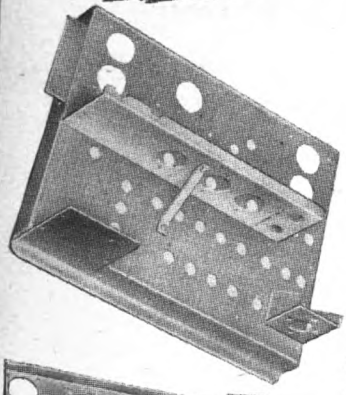

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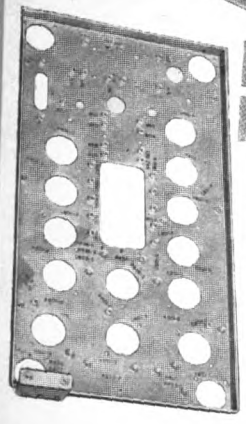

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scale before the maximu range is reached, then R_1 to keep the meter on s

The calibration obtai only for each individual distance between the lam photocell. Any change calibration necessary. Fi a typical calibration chart with the unit in the tr illustrated in Fig. 3.

After calibration has b pleted, reconnect the lam The transmitter is turne L_1 coupled to L_2 so as to

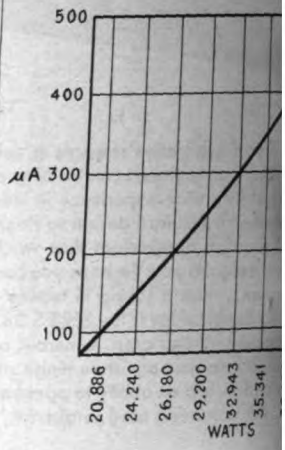

Fig. 4—Typical calibration cho tained by use of the circuit sho Fig. 2

tube draw normal plate cu The plate tank is repeated tuned for minimum plate cu while C is being adjusted for mum plate current. The co tions from the lamp to L_1 shou tried in several places for co impedance match. The proper is where the meter indicates r mum for the required input t tube.

Once the proper connection the lamp to L_1 and the correct tionship between L_1 and L_2 has established, L_1 should be fixe position. To determine the power, observe the meter read and refer to the calibration ch

• • •

Recorded Sound Waves Locate Bomb Hits

A SONIC METHOD of scoring pract bomb hits has been used at Midla Army Air Field in Texas, the A central school for bombing. T system involves recording the sou

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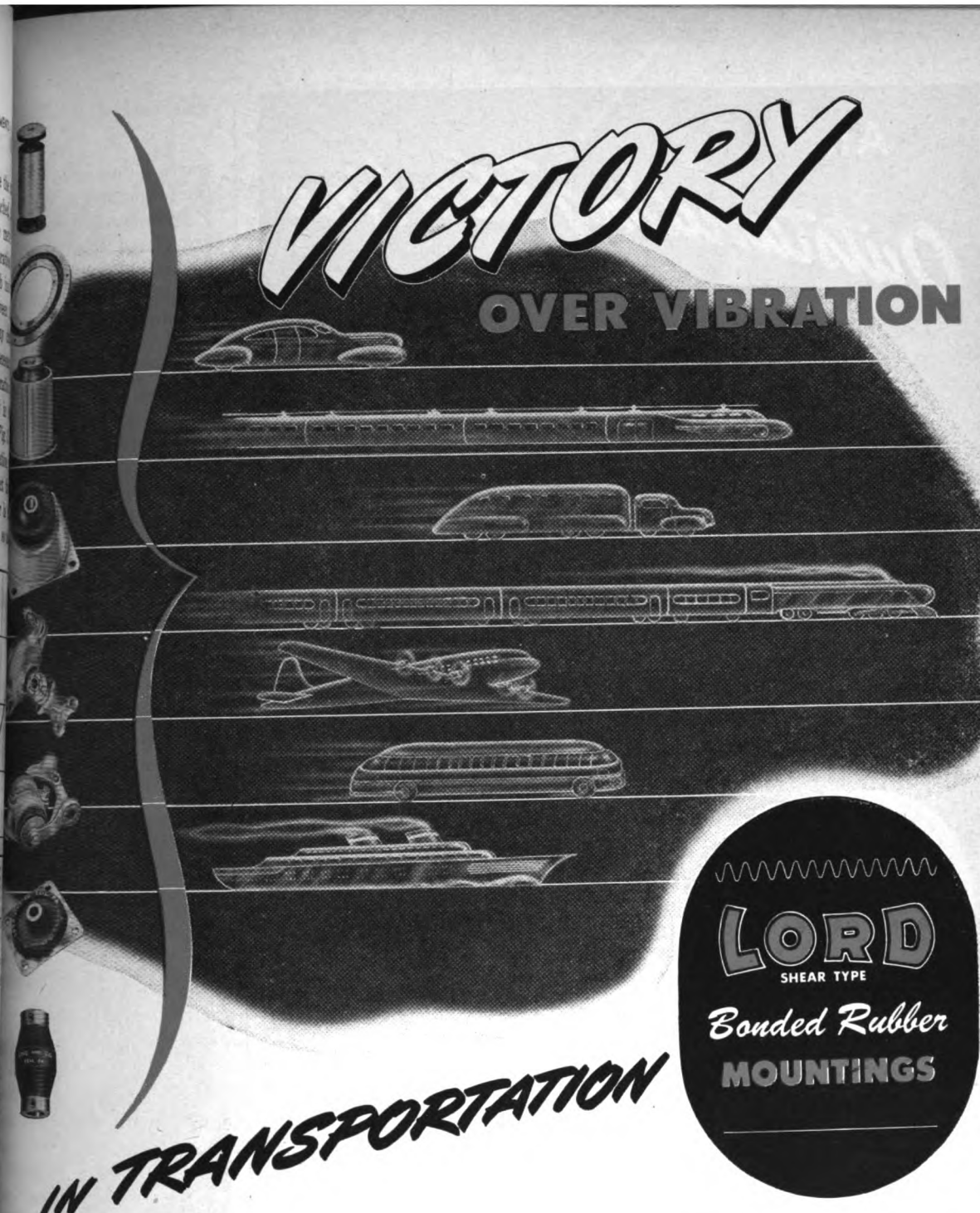

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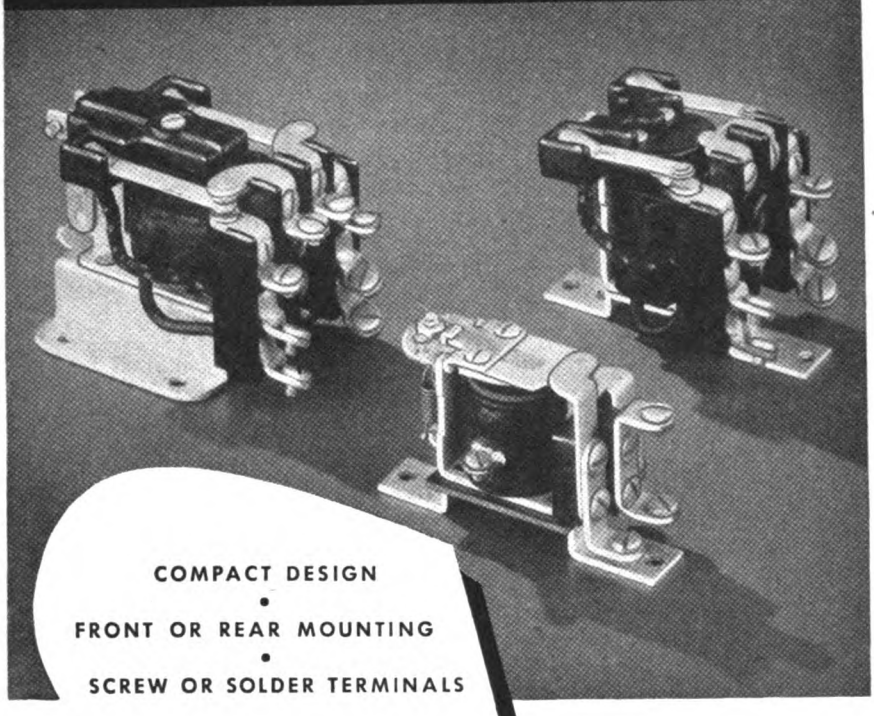

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the target area.

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are placed about the
square pattern, each 6
the target center. Eac
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explodes, the time of a
sound wave is measu
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as four individual tr
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Geophones are used
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FIG. 1—View of target a
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and one adjacent to
phone.

Figure 1 shows a
target as seen by the
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a bomb planted in th
quadrant of the target
ure 2 shows the sound
tered on the sonic s
The top trace in the

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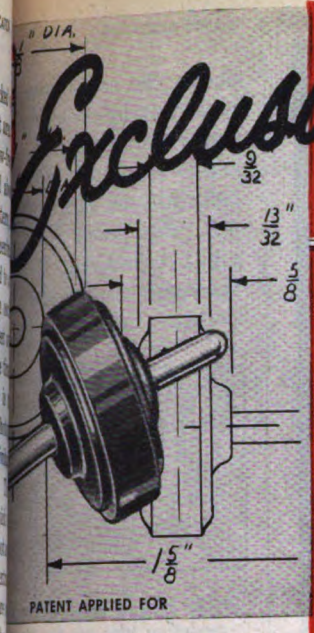

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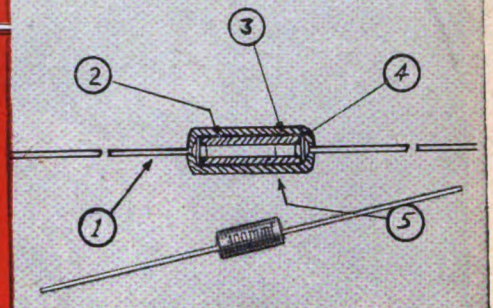

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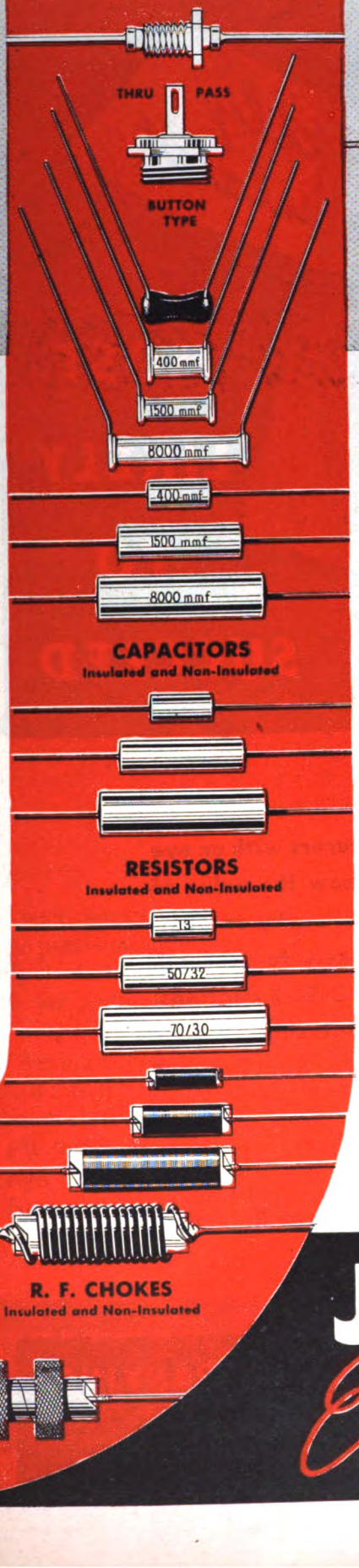

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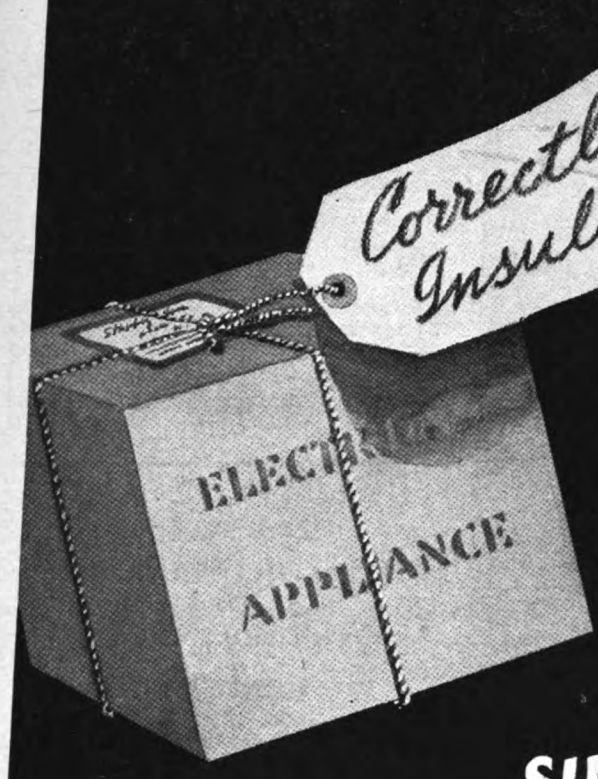

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857 MEEKER AVE., BROOKLYN 22, N. Y.

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shows the ... picked up by the mic... lower left quadrant. ... traces show that the so... next hit the microphone... left, then lower right, ... right respectively. Measu... the space between peaks ... permits the scorers to ...

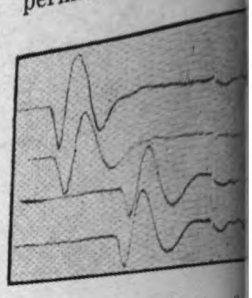

FIG. 2—The pertinent portio... recording tape are the traces ... from the four microphones, a... the clock face showing the ... impact

how accurately each pract... was dropped. A direct h... target center would show f... that coincided vertically on...

Individual bomb hits a... fied by a clock face which ... matically photographed ... time of recording. This is c... to the bombardier's recor... time of bomb impact to the ... second to distinguish his ... from that of other bomb... The circular area accura... corded has a radius of abo... feet. Bombs are seldom ... outside that area.

At Midland, the system ...

• • •

VETS BUILD RADI...

At the Army Air Forces Convales... Hospital, at Fort Logan, Colorado, ... erans build and repair commercial ... ceivers and the 90 standard mili... sets. A course in theory is also gi... at the hospital

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TRANSMITTERS by PRESS WIRELESS

RADIO TRANSMITTER PW-981-A

This compact 2500 watt, remote-control, air-cooled, radio transmitter is engineered to the same precision standards that characterize all Press Wireless communication equipment. Operating frequencies from 2.5 to 23 megacycles are available for radio-telegraph, radio-teleprinter, radio-photos and facsimile.

Amplitude ON-OFF keying speeds to 150 w.p.m. may be employed. A Frequency Shift Unit built into the transmitter permits the important advantages of high-speed frequency shift keying.

Radio transmitter PW-981-A combines simplicity of operation with carefully integrated design to occupy a floor space less than one square yard. The unit operates from a 3-phase, 220/230 volt, 50/60 cycle, 8-kilowatt power source.

Write for free engineering bulletin.

PRESS WIRELESS, INC.

Executive and Sales Office, 1475 BROADWAY, NEW YORK 18

ARMY E NAVY

Awarded to our Hicksville, L. I. plant for outstanding achievement in war production.

PARIS · BUENOS AIRES · RIO DE JANIERO · MONTEVIDEO · MANILA · BERNE · SANTIAGO DE CHILE · NEW YORK · CHICAGO · LOS ANGELES · LONDON · HAVANA

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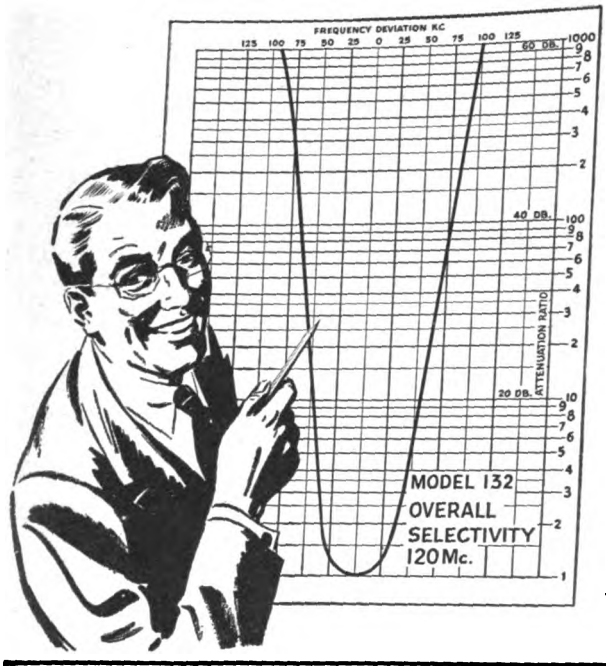
THE COMCO LINE IS *Customized*

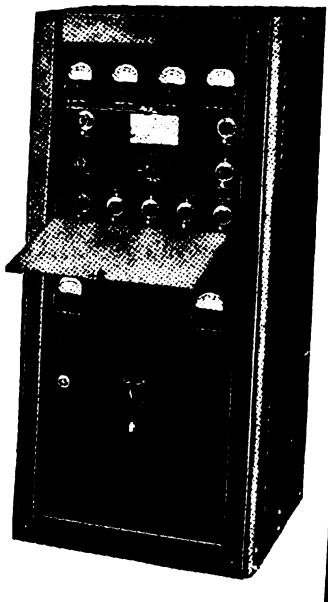
Engineered for Long Years of Dependable Performance



Painstakingly designed and built by seasoned engineers and skilled craftsmen in *limited* volume, COMCO Electronic Equipment, in every way, measures up to highest *custom* standards. Easy to service, COMCO guarantees you long years of dependable performance under all climatic and working conditions.

COMCO TRANSMITTER Model 170

Reliable VHF, 50 watts output. Frequency range 100 to 165 Mc. Cabinet size: Width 23″; depth 18″; height 48″; COMCO Model 127AA Transmitter also available for operation on a frequency range of 200 to 550 kc.



COMCO RECEIVER Model 132

Compact VHF crystal controlled, fixed frequency, superheterodyne. Single channel reception; 5¼-inch relay rack panel mounting. 12 tubes. Frequency range 100 to 165 Mc. Medium and low frequency receivers also available.

WRITE! *Just a note on your company letterhead outlining your exact requirements. We'll give you the benefit of our specialized experience. We can supply a wide variety of* customized *equipment on priority NOW. We are accepting non-priority orders for post-war delivery.*

MANUFACTURERS OF RADIO & ELECTRONIC EQUIPMENT

COMCO

COMMUNICATIONS COMPANY, Inc.

CORAL GABLES 34, FLORIDA

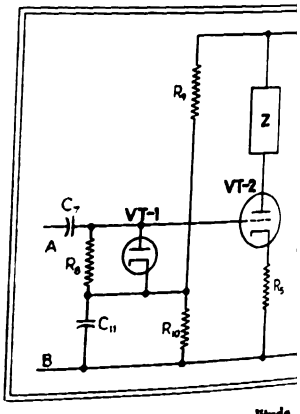
veloped under Major Edward McKaba cial projects section. A periments were made wit mographic equipment from a nearby oil com cording bomb hits with phones was found impra one thing, different types different amounts of mois soil caused variations in t of the ground tremors. A stacle with the geophones the recorder had to run during the entire bombing

• • •

Stabilized Pulse Circu

A SIMPLE AND USEFUL pul which it is claimed produc output pulses that are ind of tube or anode voltage c shown in the diagram.

Tube VT-2 is made to by pulses applied between and *B* and generates its pulse across the impedance cathode resistor R_5 introdu ative feedback and stabil anode current of tube VT-2 applied grid voltage, render amplitude of the output pul sensitive to changes of



Pulses of constant amplitude produced by this circuit

anode voltage. As negative back is used in the setup, the p applied between *A* and *B* will to be larger than usual.

Tube VT-1 acts in conjunc with capacitor C_7 and resistor form a peak wave rectifier and erates to adjust the bias on VT-2 so that the peaks of the coming pulses always reach same voltage and cause VT-2

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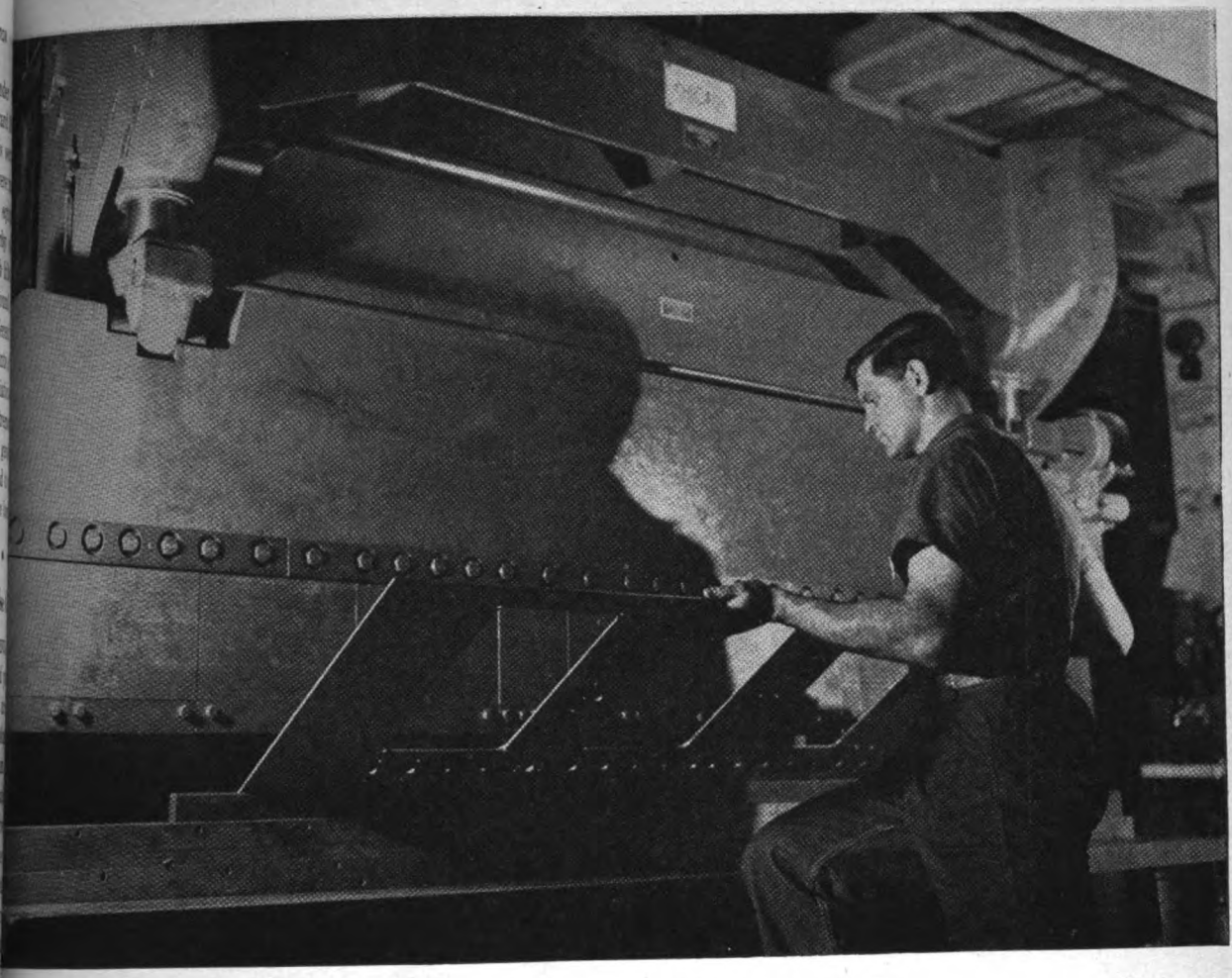
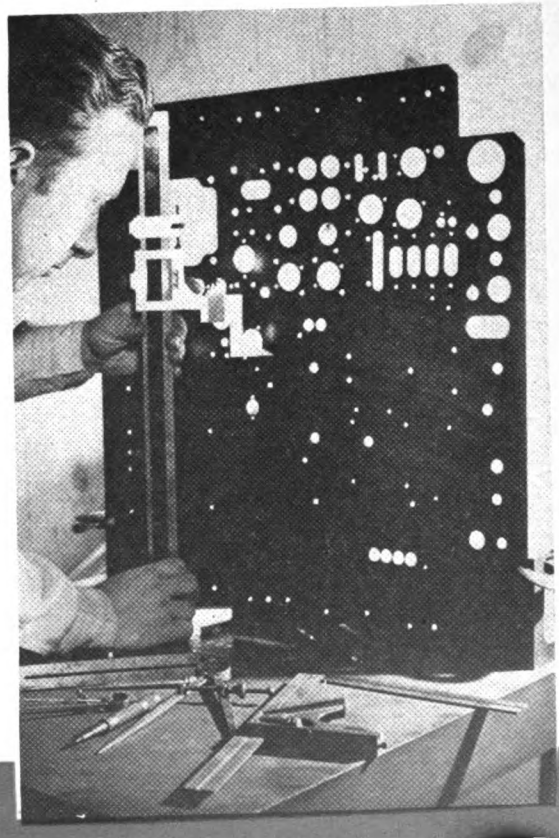


"Margin for Error" in PORTER operations

When you require sheet metal work — in any metal — and PRECISION to close tolerances is a must . . . Porter has the experience and equipment to meet your needs to your complete satisfaction.

The skilled technicians and engineers of our thoroughly modern factory stand ready to help you work out money-saving and time-saving changes in design. Also, our large stock of available dies often helps speed up production while reducing manufacturing costs.

METAL BOXES * CASES * CABINETS * CHASSIS * ODD-SHAPED FLAT PIECES * STRIPS * PANELS * HOUSINGS * ETC.



PORTER METAL PRODUCTS COMPANY

121 INGRAHAM ST. BROOKLYN, N. Y.

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● This isn't an unusual statement at all—not when you're talking about punched parts made of Laminated INSUROK! For in the electrical insulation field Richardson *precision* plastics have long been favorite materials . . . used by the millions in all shapes, sizes and thicknesses.

This outstanding preference is easy to understand, for Laminated INSUROK is an easy-to-handle product whose physical characteristics remain commercially uniform. It can be drilled, punched, sawed, turned, planed or milled in your own shop—without special tools—or Richardson Plasticians will do it for you. Write today for the full story about INSUROK . . . laminated and molded.

INSUROK *Precision Plastics*

The RICHARDSON COMPANY

MELROSE PARK, ILL. NEW BRUNSWICK, N. J. FOUNDED 1868 INDIANAPOLIS 1, IND. LOCKLAND, CINCINNATI 15, OHIO
DETROIT OFFICE: 8-252 G. M. BUILDING, DETROIT 2, MICHIGAN NEW YORK OFFICE: 75 WEST STREET, NEW YORK 6, N. Y.
CLEVELAND OFFICE: 326-7 PLYMOUTH BLDG., CLEVELAND 15, OHIO

pass the same anod
voltage at which th
applied pulses are s
controlled by varyin
resistors R_s and R_n
mine the bias on
VT-1. Capacitor C_n
pass across resistor

A variation of th
replace the cathode r
a constant resistanc
of a delay network t
a matched resistanc
ther pulses can be d
the cathode.

In the schematic,
shown as a triode bu
load presents a high
may be advantageo
pentode. The circuit
in the E.M.I. Laborato

• •

Post War Receive

By JOHN H.
London Correspo

THE DESIGN of postw
radio receivers is givi
facturers headaches,
them are sure of wha
wants. In the industry
support for the abando
e.g. magic eyes, and t
number of knobs to
Personally, I have nev
slightest justification f
dicators except as catc
tising stunts. Most pec
comparatively near ar
transmitters and th
swish enables one to tur
without fancy devices.
persistent mistuners of
chiefly women, seldom b
a magic eye if one is pr

Pushbutton tuning s
an answer to both the
and simplified control pr
I think it may be used i
the cheapest sets. My ma
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chanisms will be better
jobs.

At a recent I.E.E. disc
important speaker pointe
more attention ought to
the low-frequency end of
response band and not s
the high end. This, sadl
has a bitter taste attach
since any British radio d

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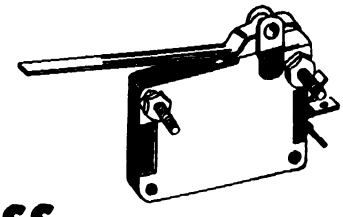
Flexibility of Design



and compactness with ACRO Switches

• Mechanism of the patented Acro Rolling Spring switch lends itself to adaptation in various shapes to fit the design of your units. Multiple mountings—flat or vertical —end to end, or side by side. Small case shapes—rectangular or curved. Various types of brackets for flexibility of mounting. Actuation pressure as low as two grams (using leaf bracket) or as high as 1 ¼ lbs. Surely one of the many ACRO Model "M" designs should fit your needs. Send your design details showing space dimensions and operating features for quicker reply.

ACRO ELECTRIC COMPANY

1316 Superior Avenue Cleveland 14, Ohio

tell you that it is eas
on good low-note r
than on good overall
the high end. One
set with a heavy,
and no high notes w
from the sales poin
though he admitted
been a slight improv
lic taste, poisoned
days of radio by set
at a maximum profit
quality of reproducti

Miniature compon
see as particularly d
dinary domestic sets
car or lightweight
may have something
but the irrational cra
in miniature has al
human beings and ra
must be on their gua
The Lord's Prayer h
ten on a grain of rice
nique has little to co
everyday life and any
Bedford of Cossors ha
the greatest obstacle i
miniature components
body has yet invented
watt.

Narrow-Band Relay

simple but useful ide
limited-frequency-respo
mitters for the relayi
quality broadcast p
brought forward in th
issue of *Wireless Wo*
Stockman, editor of *Po*
Stockholm.

He proposes to reco
gram on disks or tape
this canned version, runn
normal speed, to modulat
mitter. The
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as the speed
same relative

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it could be red
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noise level wou
would also be
tive fading.

At the receiv
gram would have
then reproduce
Since many
have recordin

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GOOD NEWS FOR BROADCASTERS!

REL 88-108 Megacyle Band

FM BROADCASTING TRANSMITTERS in ASSEMBLY

PLACE YOUR ORDER NOW!

These REL broadcasting transmitters can now be ordered . . . to meet or exceed present FCC requirements.* Entirely new . . . with important design advancements in the Armstrong Modulator . . . providing simple, stable . . . even more efficient performance than ever before!

Power Output	Cat. No.
250 watt	549 ADL
1000 watt	518 ADL
3000 watt	519 ADL

Note: Future REL advertisements will give you information regarding transmitters of higher power. Watch for them!

Wire or write today for technical data, prices and delivery . . . or better yet . . . do as other broadcasters have already done—send your order, subject to later confirmation, thus assuring early delivery.

*REL FM Transmitters are guaranteed to meet or better the FCC standards of good engineering practice for FM Broadcast stations.

REL

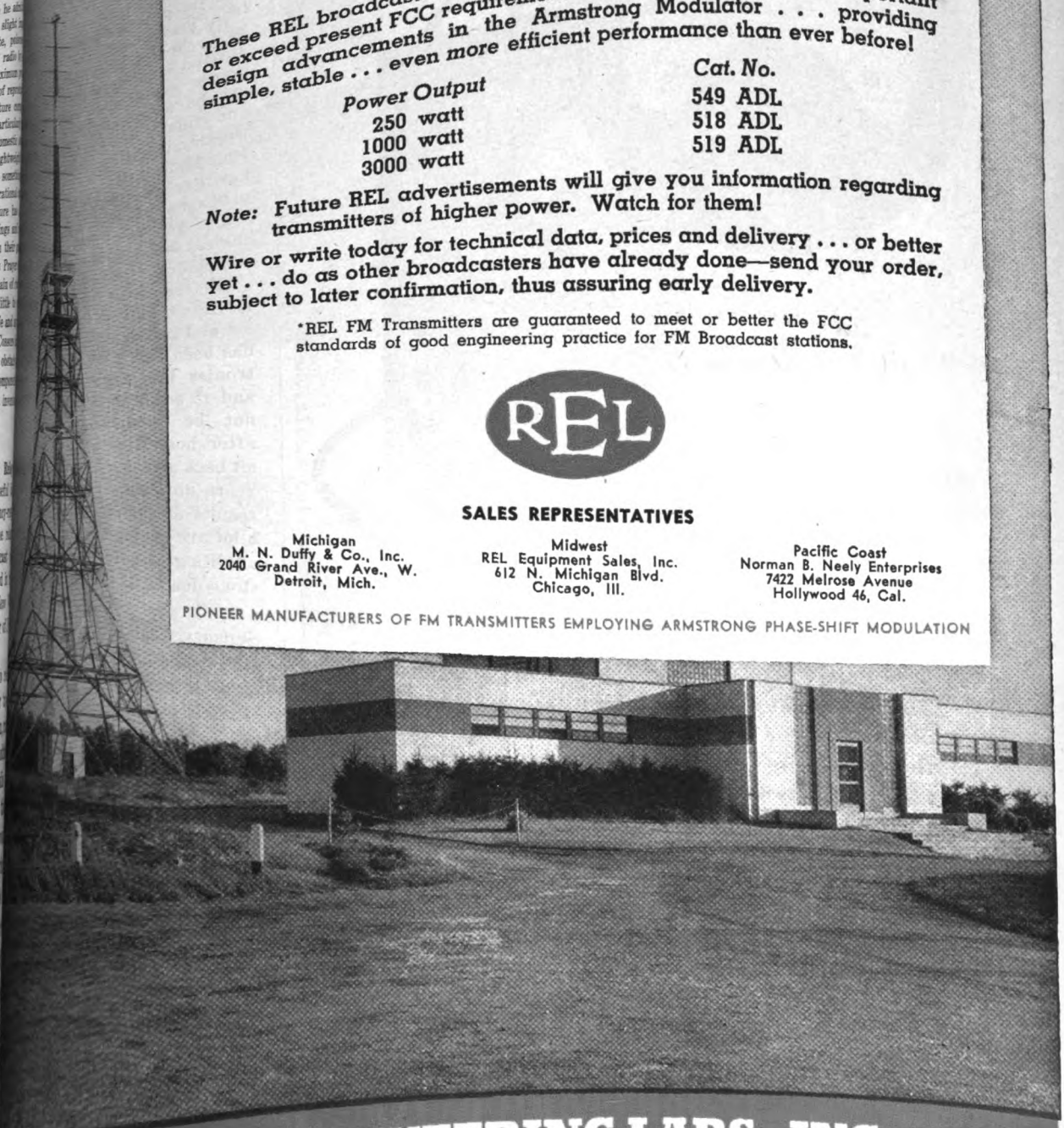
SALES REPRESENTATIVES

Michigan
M. N. Duffy & Co., Inc.
2040 Grand River Ave., W.
Detroit, Mich.

Midwest
REL Equipment Sales, Inc.
612 N. Michigan Blvd.
Chicago, Ill.

Pacific Coast
Norman B. Neely Enterprises
7422 Melrose Avenue
Hollywood 46, Cal.

PIONEER MANUFACTURERS OF FM TRANSMITTERS EMPLOYING ARMSTRONG PHASE-SHIFT MODULATION



RADIO ENGINEERING LABS., INC.
Long Island City, N.Y.

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ELECTRONIC AC VOLTMETER
with Logarithmic Scale

Percentage Accuracy of reading is uniform over entire scale!

MODEL 300
ELECTRONIC
VOLTMETER

ACCESSORIES
MODEL 220 DECADE AMPLIFIER
MODEL 402 MULTIPLIER

Since its development in 1935 the Ballantine Electronic AC Voltmeter is the only instrument of its kind with a Simplified Logarithmic Scale.

The important feature of logarithmic scale indication in the Ballantine Voltmeter provides the same degree of accuracy at 1 as at 10. Also the simplicity of this scale reduces errors in visual observation, common with most multi-range instruments. Finally, the care taken in overall calibration combined with the inherent stability of the circuits used permits reliable readings within the 2% specified tolerance over the complete range of operation.

Write for descriptive technical Bulletin 8

BALLANTINE LABORATORIES, INC.
BOONTON, NEW JERSEY, U. S. A.

ing this new
the cost of increa
time.

A 5:1 ratio ha
that is, a program
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of 100-5000 cps r
handled by one of

Television Talk.
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as to how televisio
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system should be
and equally good en
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100 Mc carrier fr
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programs from c
Wave guides—u-h-
cables; nobody seem
compelling ideas on

On the other sid
sits the man who is
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tronics has done d
and if something re
not be produced
after hostilities ceas
sit back and say, "I'll
years until sets get
results are worth see
a lot are saying that
anything is going to
stone-dead it is that k

Sensory Electronics.
who could well bene
more intensive resear
tronicists are the d
blind. Deaf aids ce
but it is high time tha
taken to redesign ther
duce the exorbitant
are charged. Similarl
do much more to make t
accessible to the blind.
Library of the Nation
for the Blind in Great
only 464 books recorded
age number of disks fo
is 10. They are doublesi
with 200 grooves to th
playing at 24 rpm.

Transparent Ultraviol
One of our war-time ch
coveries which has prove
ful to the engineer is a p

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A new and effective sales feature for your newly designed appliances

what is the Belden CONNECT-A-CORD?

Appliance users want this new advantage

The Belden Connect-A-corD is a new idea—but already surveys show that considerable percentages of electrical appliance users want its advantages. No mere postwar dream, the Belden Connect-A-corD is already engineered. It is offered now only after a thorough check establishing a customer demand for it on better electrical equipment.

Detachable at *both* appliance end and plug end, Belden Connect-A-corDs are something new in electrical cords. They greatly simplify line assembly, packing, and product display, and they add still another effective sales feature to your newly designed electrical appliances. Available in matching colors and in almost any length, Connect-A-corDs are completely interchangeable—ending the nuisances of too-short-to-reach cords and tangled coils of extra lengths.

Connect-A-corDs eliminate dealer cord repair service and, like all other Belden electrical cords, offer complete freedom from Corditis. Also, consistent national advertising pre-sells Connect-A-corDs to your customers. Write for information today.

Belden Manufacturing Company
4625 W. Van Buren St., Chicago 44, Ill.

Belden

Corditis-free CORDS

ARMY NAVY
Chicago, Ill.

ARMY NAVY
Richmond, Ind.

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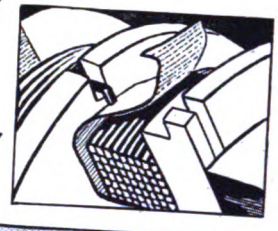
Why MEPCO "Tru Tolerance" RESISTORS are "Tops" with Manufacturers of Instruments, Radio, Electronic Equipment

They're Triple Improved!



ACETATE LABEL
Tougher, cleaner, more durable covering. Protects winding from mechanical handling. Prevents lugs from piercing label. Affords fungus protection to winding.

ADDED INTERNAL INSULATION
Cross-over wires are insulated from rest of winding with acetate cloth. An exclusive Mepco feature (patent pending).

DOUBLE SEAL IMPREGNATION
Prevents breakdowns and shorted turns. Withstands humidity and salt spray tests better. Is fungus resistant.

Non-Hygroscopic Ceramic Forms: High insulating value, low expansion coefficient, high mechanical strength.

Highest Grade Alloy Wire: Especially enameled to meet most rigid tests.

Extra Terminal Protection: Lug type winding leads and lug embedded and molded into one unit. Lead wire type securely anchored in grooves with winding wire protected so as to prevent possible breaking in handling.

True Tolerance Precision Resistors: Standard tolerance 1%. Special tolerances down to 0.10% on special orders.

Severe Breakdown Test for every unit. Rejections minimized by special winding technique which prevents chafing of wire.

Careful Calibration and precision winding keep all units well within specified tolerances.

Send us your requirements on special resistors for quotation.

GET THE MEPCO RESISTOR GUIDE. IT'S FREE! Shows all Mepco standard sizes and gives complete data as to electrical and mechanical characteristics.

E Madison Electric Products Corp. Madison New Jersey

NAME.....

POSITION.....

ADDRESS.....

CITY.....STATE.....

MADISON ELECTRICAL PRODUCTS CORP. MEPCO ELECTRIC · RADIO · ELECTRONICS

MADISON ELECTRICAL PRODUCTS CORPORATION
MADISON, NEW JERSEY
Precision Resistors . Thermocouples
Voltmeter Multipliers
Electronic Specialties

is opaque to ultraviolet li transparent to visible ligh

The problem arose in co with instruments on the panels of aircraft, where u is sometimes used to rend markings clearly visible to t

A snag arose, however, w tain equipment involved th ence of a cathode-ray tube panel, since u-v light cau whole of the phosphor to gl so the trace was effectively ated.

Research showed that th tion lay in spraying the en of the c-r tube with a c nitro-cellulose laquer contai little picric acid. This effe blocked the u-v but did not de the visibility of the tube tra

Shipyard Strain Gages. I in *Shipbuilding* that resi strain gages have been us marine boiler investigations. 0.001 in. in diameter was wou a flat form and bonded in the manner with resin-impreg paper. A particular researc volved the strains on boiler p the experimental method bei work on a test box having p representative of those in the bustion chamber of a boiler.

Random Radiations. "The p which has to be measured (c talk between carrier channels) be less than a hundredth of a llionth of a microwatt. As heat ergy, this is roughly equal to from a 60 watt lamp falling o collector one foot square at a tance of 4000 miles."—W. G. E ley. (G.P.O. Research Station).

Radioplanets To Order. An o cial of the British Interplanet Society has brought forward an teresting, and apparently qu sound proposal based on the t mendous speed of the Nazi V weapon. He points out that if rocket could be given a velocity about 8 kilometers per secon (about 3 times that of V-2) it coul be sent up to the stratosphere an would circle the earth forever, a an artificial satellite.

The value of the device would li in the fact that it could carry mete orological instruments and radio the readings back to earth at regu-

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..., as before, expect quality leadership
...ollins broadcast equipment

THE NEW COLLINS AM transmitters and remote amplifiers, now ready, reflect characteristically advanced Collins engineering.

Notable transmitter refinements include extremely high fidelity, and increased safety factors through the use of oversize components throughout.

The Collins 21A is a superb 5,000 watt transmitter, with reduced power operation at 1,000 watts also available. Its response curve is flat, within ±½ db, from 30 to 10,000 cycles.

The Collins 20T is a 1,000 watt transmitter, of similar characteristics, equipped for reduced power operation at 500 watts if desired.

The Collins 300G is a 250 watter of equal fidelity, with reduced power operation at 100 watts available.

The Collins 12Y one channel remote amplifier is light, handy, simple and efficient. It is for unattended operation from a 115 volt a.c. power source.

The Collins 12Z four channel remote amplifier is a.c.-d.c. powered, the d.c. source being self-contained batteries which take the load automatically in case of a.c. line failure.

A complete line of Collins high-quality studio equipment is available for either AM or FM application.

An outstanding broadcasting station begins with outstanding equipment. We will be glad to know about your plans and submit complete recommendations. For additional detailed information, write the Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y. Collins equipment is sold in Canada by Collins-Fisher, Ltd., Montreal.

...FOR BROADCAST QUALITY, IT'S...

COLLINS

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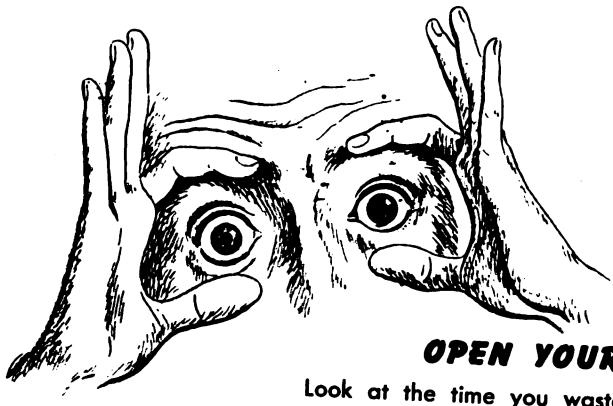


OPEN YOUR EYES

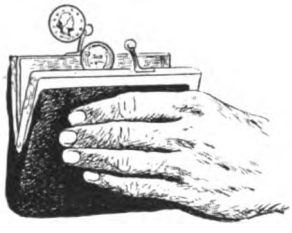
Look at the time you waste making smudges and trying to unmake them . . . on tracing paper. Look at the foggy reproduction. Then look at Arkwright Tracing Cloths.

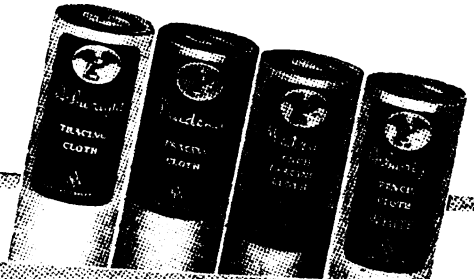
A CHOICE THAT'S WISE

Arkwright Tracing Cloths have the surface for clean erasing and easy, clear re-inking . . . and the transparency to give sharp reproduction.

A WAY TO ECONOMIZE

It's what you get for what you pay that determines cost. In Arkwright Tracing Cloths you get time saving, quality saving and a plus . . . durable transparency. Prove it by writing today for free samples. Arkwright Finishing Company, Providence, Rhode Island.





Sold by leading drawing material dealers everywhere

Arkwright

lar intervals. Revolving
hours it would be with
range of half the earth'
and three receiving statio
grees apart would be suff
receiving the data. Batter
of course, only have a li
but it is suggested that
and thermo-couples could
switch off the electrical
much of the time and so
the period over which we
results.

Photo-Mechanical Oscilla
medical and other biolo
search, it is sometimes re
produce oscillations at a f
below 10 cps and two int
pieces of equipment for p
these were described in *E
Engineering* recently.

The first was simply a
disk revolving in front of a
aperture through which
passed on to a photocell.
1-watt bulb and a recti
cell the output was 5 mv
quencies between 1 and 100
only about 5 percent odd ha
in the waveform.

A rather more complic
rangement of this principle
waves to be synthesized, w
phase and amplitude of ha
up to the tenth, controllab
respect to the fundamental.

Two disks are used, each
with five rings of holes, o
giving the fundamental, 3r
7th and 9th harmonics wh
other has spacings to give th
4th, 6th, 8th and 10th. A
photocell is mounted opposit
ring and each cell is mounted
lever, so that it can be rotated
an axis in line with the disk
dle. This allows phase adjus
Potentiometers connected
the cells give amplitude
ment.

A variable-speed phonograp
tor is used for driving purposes
a carefully prepared strobosc
disk, used in conjunction wit
neon lamp, allows accurate
quency determination. The out
of the apparatus is 0.5 mv in
range ¼-4 cps and owing to the
output it was found necessary
screen the driving motor w
Mumetal.

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SISTANCE WELDING

SIMPLIFIES SMALL PART ASSEMBLY

FTLY, ACCURATELY, WITH S NEW ELECTRONIC TIMER

minum and copper welding gain new acy with this Westinghouse electronic SP-18 cle welder control. Heat control is precise swift over a stepless range of 4 to 400% of al heat available with full cycle timers. unit is admirably suited to the resistance ng of radio tube parts and sockets, pig-tailed tors to terminal lugs, watch and instrument , electrical relay contact tips, toys and lar small parts.

Welding current starts at exactly the same t on the voltage wave on every operation. *maging transients are eliminated.* Rejects reduced. Welds are exact duplicates. The brated heat-adjustment dial is quickly set for ration and no time is lost setting controls welding precision parts.

Available for either wall or bench-mounting, e one-shot operations of the Westinghouse P-18 require no sequence timer. You can learn ore about this improved electronic welder ontrol from your nearest Westinghouse office. r write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa. J-21319

The improved, simplified Westinghouse SP-18 welder control measures only 14½" x 20" x 12½". Note complete accessibility of interior of the unit by simply unlocking hinged panel. The control Thyratron is shown on the front of the swinging panel while the air-cooled Ignitron is mounted directly behind it.

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Electronics at Work

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THE ELECTRON ART

Conversion from Series to Parallel Impedance 254
Two-Voltage Regulated Power Supply 254
Square-Wave Modulator for Signal Generator 260
Permeability of Iron at Radio Frequencies 268
Universal Electronic Indicator for Aircraft 280
Aviation's Electronic Requirements 288
Medical Probe 300

Conversion from Series to Parallel Impedance

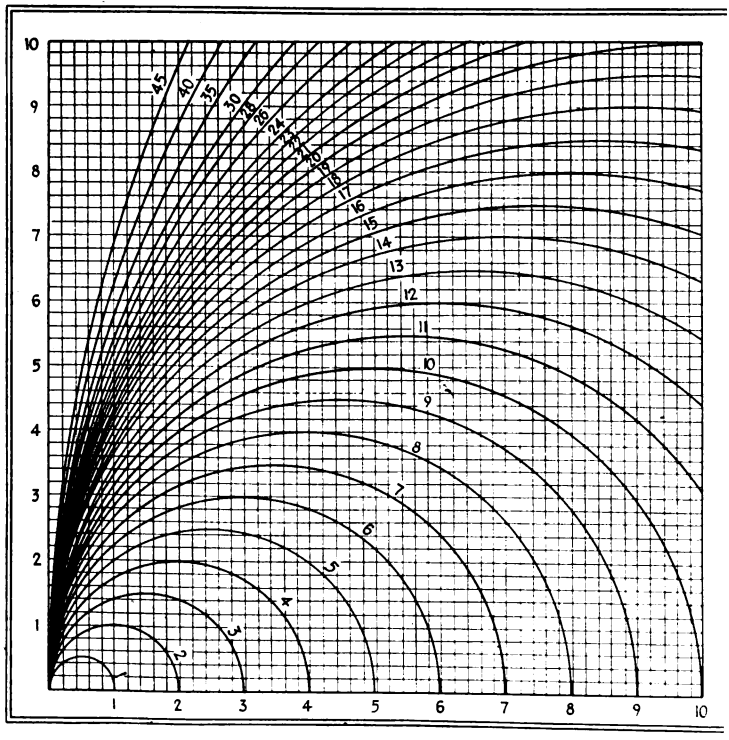
By GERSHON J. WHEELER

IMPEDANCE MEASUREMENTS made on r-f bridges are usually determined in series form $R \pm jX$, but in many applications, it is desirable to know the equivalent parallel impedance; that is, that value of resistance and reactance in parallel which will have an impedance equivalent to that measured on the bridge. The accompanying graph presents a quick method for determining the equivalent parallel resistance R, and reactance X, when the series resistance R, and reactance X, are known.

To determine the value of *parallel resistance*, enter the value of series resistance on the horizontal axis and the value of series reactance on the vertical axis. The number at the right-hand end of the arc at which these coordinates intersect is the value of the parallel resistance.

To determine the value of *parallel reactance*, enter the value of series reactance on the horizontal axis and the value of series resistance on the vertical axis. The arc now indicates parallel reactance.

The arc indicates the parallel value of whichever series component was entered on the horizontal axis. The units may be ohms, tens



Graph for converting resistive and reactive series-impedance components into equivalent parallel-impedance elements is constructed from circles the locus of whose centers are on the horizontal axis of a rectangular coordinate system

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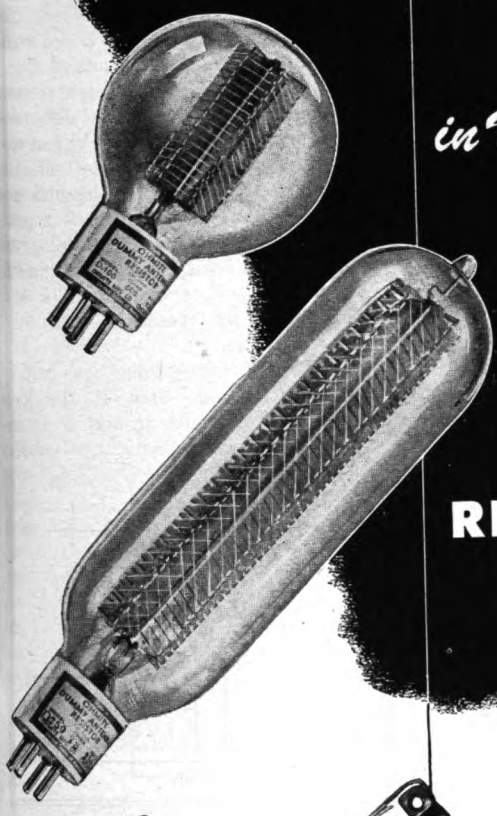

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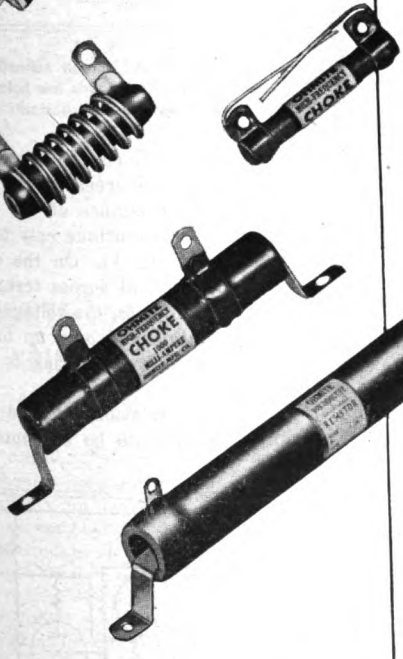

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across terminals D an
tive voltage across te
F. Tubes V_1 and V
nected that the poten
between the cathode
minal B will remain
value determined by
plied between termin
By a suitable choice
output voltage betwee
and F may be made
other desired fraction
ply voltage.

This arrangement
limitations in that,
across terminals D a
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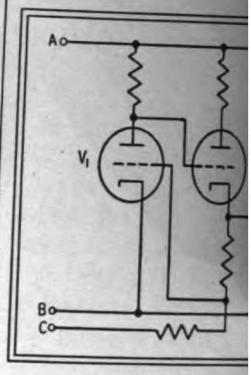

FIG. 1—Simplified circuit
applications where loads a
and essentially con

at E will tend to rise; th
resisted by an increase i
to cathode resistance of
pensation can continue o
cut-off point of V_2. On
hand, if the load across
E and F increases, the vo
can be maintained only
point at which V_2 begin
urate.

If large variations of
rent are likely to be enc

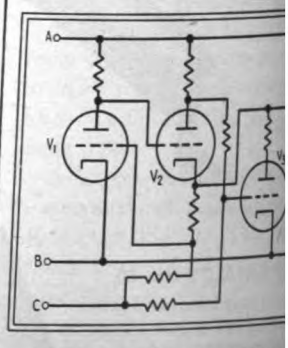

FIG. 2—The addition of V_3 p
for constant voltage division
fluctuating loads

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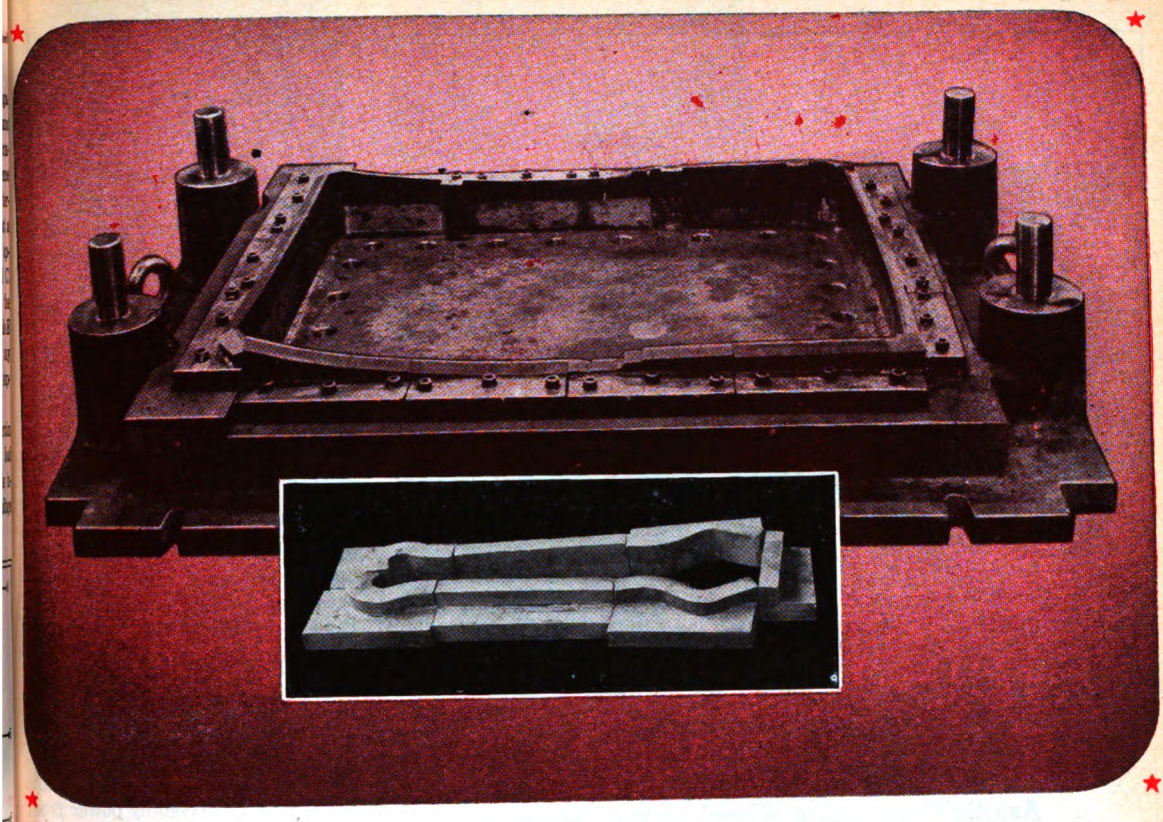

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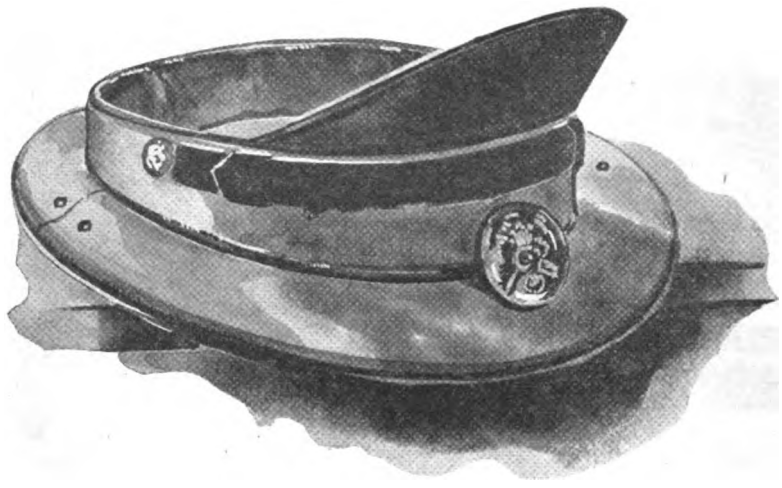

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the circuit of Fig. 2
ferred. The plate-to-
ance of V_s appears ac
E and F. With th
coupled to the plate o
to-cathode resistance
varied in the opposite
of the plate-to-cathod
V_s, permitting greate
loads before the cha
V_s begin to limit reg

• •

Square-Wave Mod
Signal Generator

DESIGN DETAILS and
hints on apparatus fo
lating the output of
quency standard sign
are described in an art
Piggott in *Wireless En*
set House, Stamford
S. E. 1) for March 19

The equipment consi
tralized, push-pull, cath
electronic switch used
tor, and a simple puls
which may be driven by
the a-c line or by the o
audio oscillator. The
shown in Fig. 1, and th

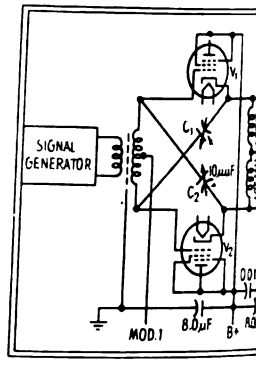

**FIG. 1—Push-pull cathode-fol
cuit used to impress pulse
on output of high-frequen
generator**

erator, shown in Fig. 2,
signed to operate as a uni
common power supply.

Application of the push-
ode-follower offers several
advantages as a modulat
output impedance, appre
unity stage gain, and indep
of changes in tube operati
ditions. High-frequency cu
fed to the grids of the h
tubes through the input
former. The tubes are bi

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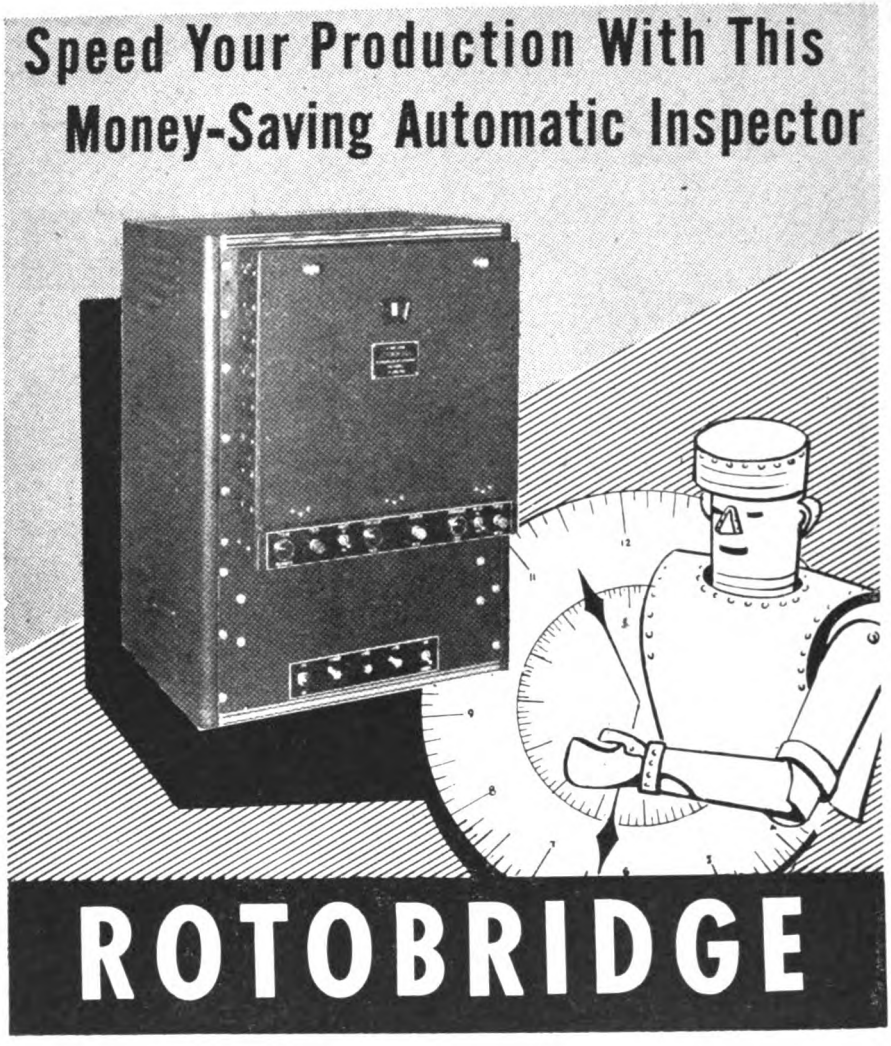

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cutoff, and any sig
the output termina
age through the
capacitances of th
leakage is balanced
back small out-of-
from the cathodes
tors C_1 and C_2. In
loads are used to p
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and the resistive
shock excitation of t

Feeding a square
pulse from the puls
the grids of the m
reduces the effective
these tubes, permit

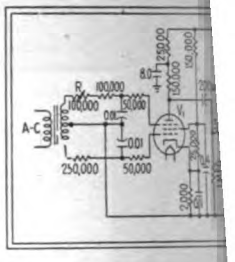

FIG. 2—Pulse-generator c
square wave of variabl
audio-frequency sin

tion of the r-f signal t

Square-wave, positiv
obtained from the circu
when sine-wave a-c is f
a-c line or an audio-fre
lator, to the input tran
through the phase-shif
to the control grid an
grid of V_1. The puls
rate is determined
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pulse length by the
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two grids. When the

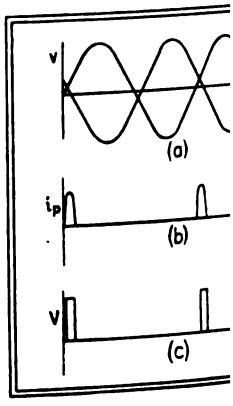

FIG. 3—Graphic repres
ing development of squ
vector sum of voltages
grids

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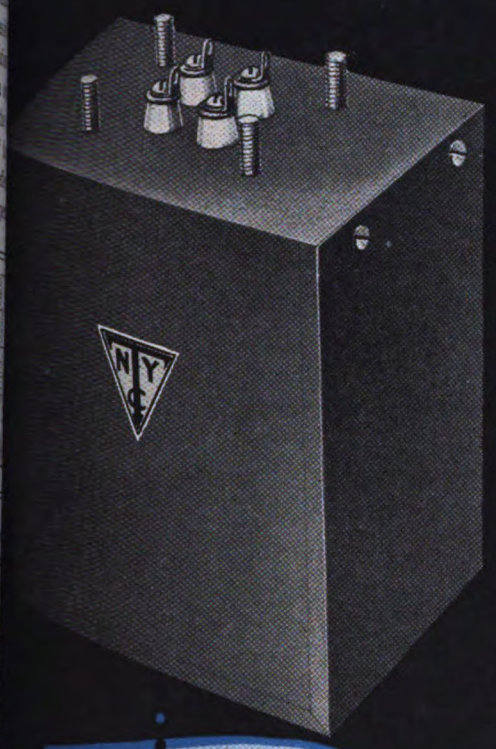
The "chance" factor...

eliminated in transformer production by N·Y·T engineers



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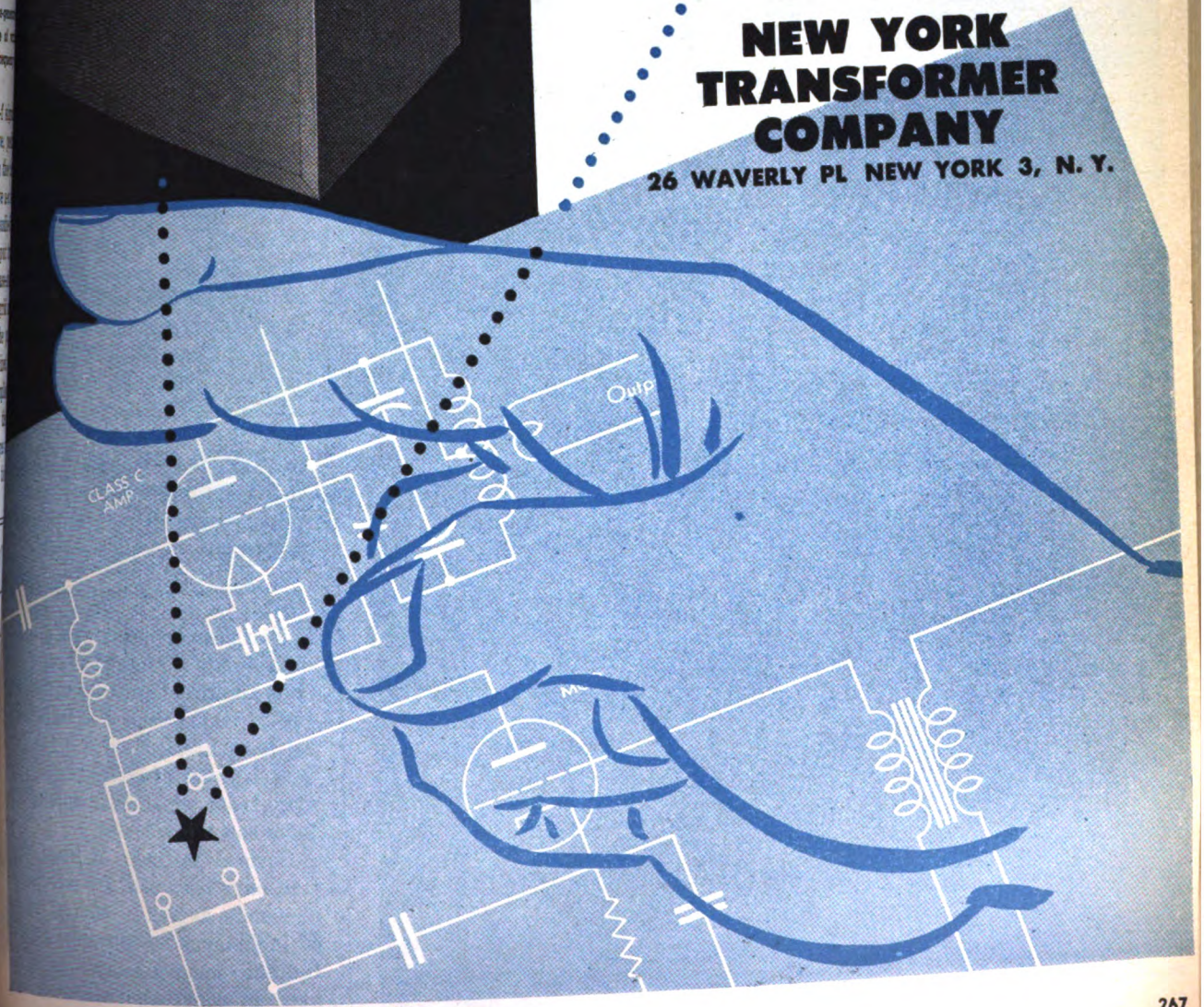

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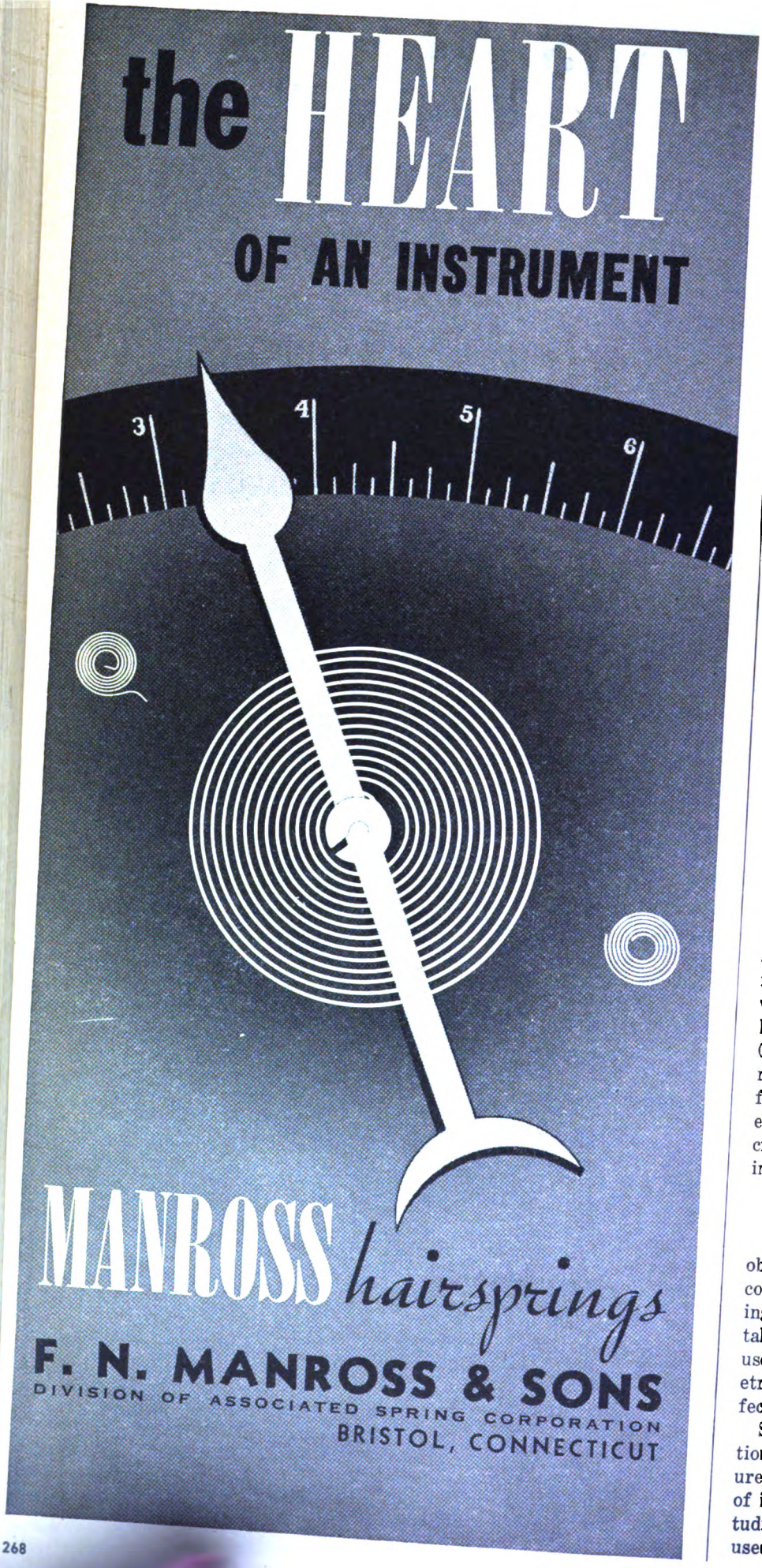

to the grids are exactly
phase, no plate curren
by V_1. Adjustment of
will produce a phase s
voltage applied to the
grid, and plate curren
during a part of the cyc
graphically in Fig. 3. T
veloped in the plate circ
amplified and squared
pearing at the output te
the pulse generator in
shown in Fig. 3(*c*). The
pulse width available
given input voltage is inv
portional to frequency, th
cuit producing a 10 μsec
50 cps, will produce a 0.1
from 5000 cps.

Careful attention to sh
components and units, an
ing and orientation of co
is necessary to obtain
stable and consistent oper

The device has many ap
in pulse field-strength
ments, and measurement
transient behavior of tra
lines, antenna systems and

• • •

Permeability of Iron a Radio Frequencies

MAGNETIC PERMEABILITY o
diameter iron wires was m
at low field intensities in a
ing fields of from 54 to 1150
wavelength by Alva W. Smit
Dickey, and S. W. Foor w
Ohio State University. The
reported in the *Jour. App.*
for Jan. 1945, indicate that
ent permeability decreases w
crease in wavelength and in
in wire size.

Permeability Measurement

The measurements were ma
obtain data for design of iron-
coils and to enlarge our unders
ing of magnetism. For experi
tal measurement, iron wires
used because of their simple g
etry from which eddy current
fects can be evaluated.

Several methods of magne
tion have been used for such m
urements, as well as different me
of inductance measurement. Lo
tudinal magnetization has b
used in connection with measu

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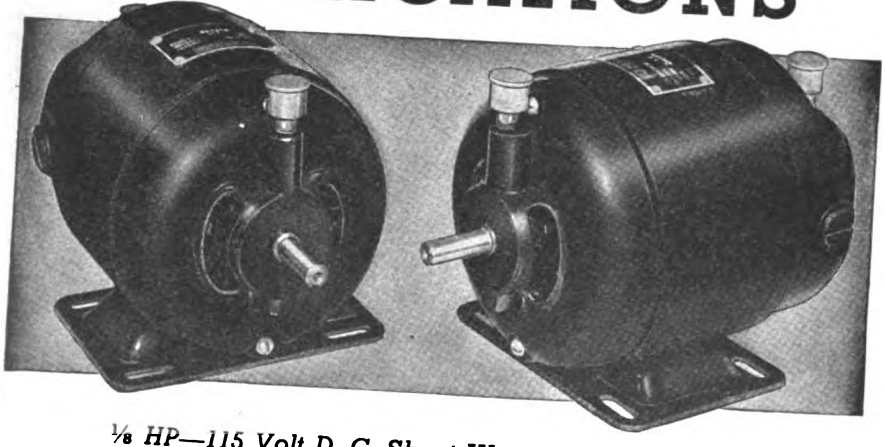

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ments of the change in induc of the magnetizing coil resi from introduction of the spec Circular magnetization has used with wavelength measure of the electro-magnetic wav Lecher wires made from the ple, or with measurements o change in radio-frequency tance of the specimen as d mined from bridge or resonanc servations—depending upon frequency range to be covered.

There are three high-frequ permeabilities recognized in th erature. From the change-in-r tance method there comes μ_s c lated by skin-effect formulas. circular and longitudinal magn zation there is μ_L calculated f inner self-inductance formulas. both cases it is necessary to cor for the non-uniformity of ra flux distribution within the sp men.

By correcting for eddy-curr effects in the μ_L permeability, apparent permeability μ is obtai The permeabilities presented this paper are apparent.

Measurement Circuit

Permeability was determin from change in inductance of specimen coil in an oscillati circuit. Inductance changes we calculated from changes in capac tance necessary to restore th oscillating frequency to its initi condition after the specimen wa inserted in the coil. Frequency wa measured by double heterodyning first by a fixed radio-frequency os cillator to an audio frequency, an then by a fixed audio-frequency os cillator to a second-order audi beat. When the two radio-frequency oscillators were at the same fre quency, there was no second-order beat.

Figure 1 shows the essential features of the apparatus. A General Radio wavemeter was used to determine the operating frequency. The two tank coils L_1 and L_3 in the specimen oscillator were magnetically and electrostatically shielded, and the specimen coil L_2 was electrostatically shielded from the specimen which was inserted axially. L_2 was wound to form a coil about

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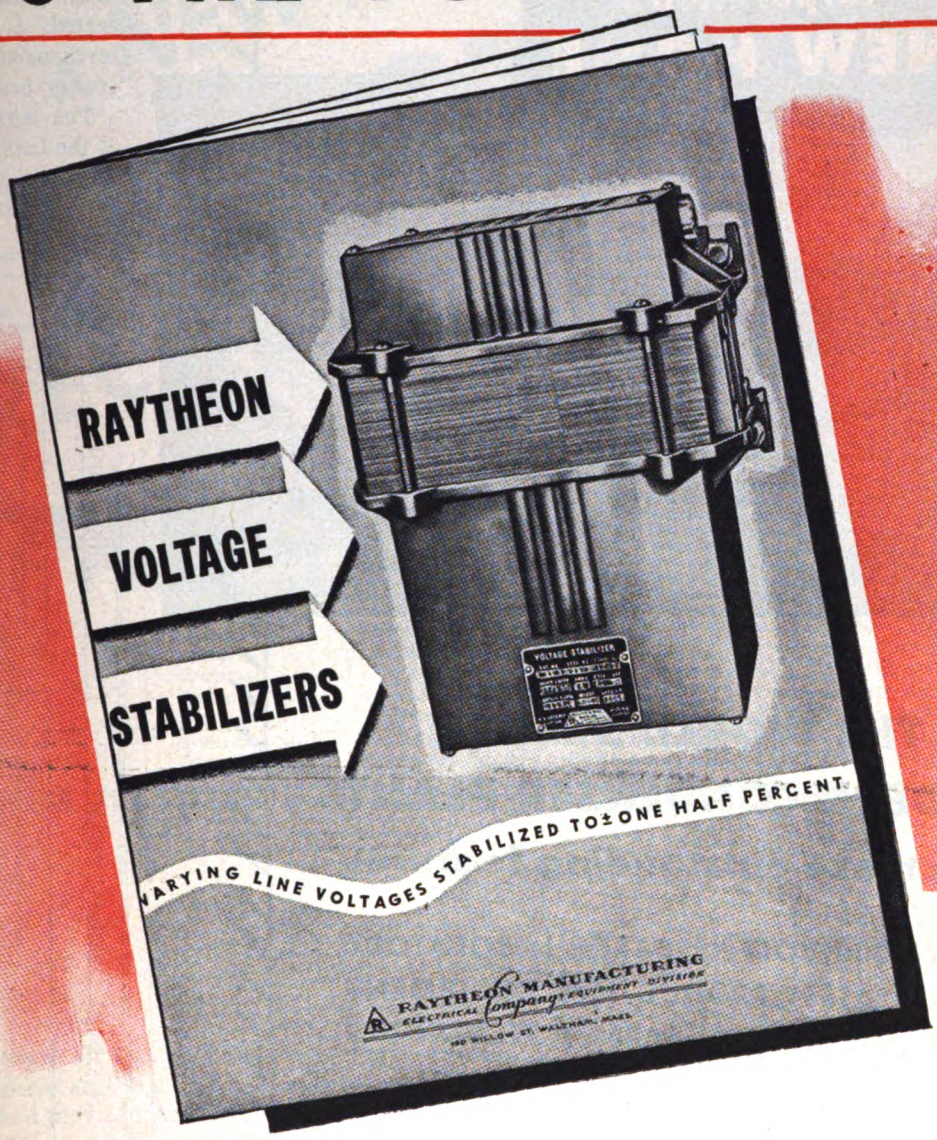

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16 cm long to assure a unifo
into which the specimen
serted. L_1 was a plug-in
terchangeable for change
quency bands.

The series-parallel arra
of the tank capacitors incre
accuracy of measurement
quiring a large change in

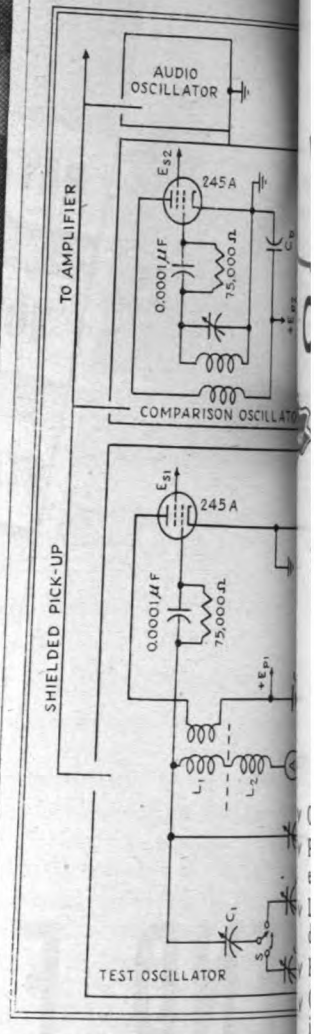

Fig. 1—Test circuit for measuremen permeability of iron wire at h frequencies

to produce a small change in e
tive tank capacitance. The two
pacitors C_{S1} and C_{S2} were Gen
Radio precision capacitors aga
which the other capacitors w
calibrated. Mercury switch S op
ated by the same pulley system t
moved the specimen in and out
L_2, switched one or the other pre
sion capacitor into the circuit. T
difference in capacitance betwe
C_{S1} and C_{S2}, when operation of t
specimen-switch system produc
no frequency change, is indicat

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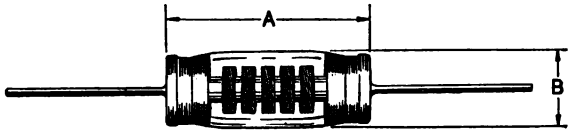
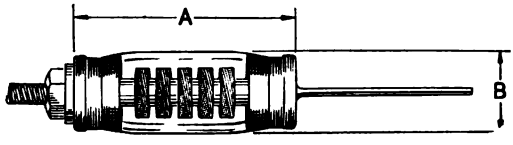


MILLI-HENRIES	A	B
1.0	1-3/4"	5/8"
2.0	1-3/4"	5/8"
2.5	2"	5/8"
5.0	2"	11/16"
10.0	3"	11/16"



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of the reflected inductance of the sample.

A Western Electric vacuum thermocouple and galvanometer were used to observe that the current in the specimen coil remained constant at a known value. Current was controlled by the screen-grid voltage. The d-c component of the grid current produced negligible magnetic effect.

The chemically pure iron-wire specimens were enclosed in individual sealed glass capillary tubes. Groups of from one to twenty wires enclosed in a larger tube constituted a test sample. The test samples were carried to the same position in the coil at each insertion.

Results and Conclusions

Logarithmic plots of permeability against wire diameters indicate that permeability μ varies inversely as the 0.9 power of the diameter. Although measurements were made

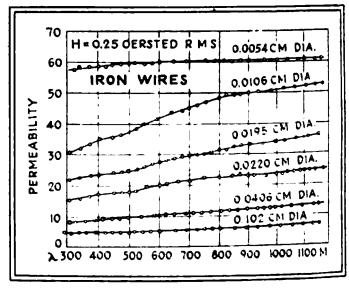

Fig. 2—Permeability as a function of wavelength for several sizes of iron wire

at low flux densities where permeability is assumed to be constant, the data seemed to indicate an increase in μ with increasing H.

The decrease in permeability with decrease in wavelength and increase in wire diameter indicated in Fig. 2 is caused by the reduction in flux produced by eddy currents flowing in the cross section of the wire. These eddy currents produce a counter mmf that increases with wire diameter and conductivity and decreases with wavelength.

• • •

Universal Electronic Indicator for Aircraft

WITH THE LARGE-SCALE development of commercial aviation just around the corner, consideration is being

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given to more simplified instrumentation in aircraft. Proposals for a single indicator for presenting instrument readings to a pilot is described by P. Postlethwaite in *Electronic Engineering* (43-44 Shoe Lane, London, E.C. 4) for November, 1944.

The author takes as his starting point, the screening of an outline of the plane on a cathode-ray tube. Below the tube is a gyro mechanism and an artificial horizon bar which is arranged to move between the cover glass of the instrument and the screen of the tube. That much is mechanical.

Surrounding the c-r screen is a compass scale, while in front are a horizontal scale of speed and two vertical scales; one for height and the other for rate of climb or descent. Presentation of the various conditions of flight is made in the following ways:

Air Speed. The measuring mechanism is made to vary the gain of the c-r tube amplifiers and so vary the size of the outline. The wing tip acts as a pointer to read against the horizontal scale of speed.

Ground Speed. This is presented in a similar way, using a radio beam in conjunction with the Doppler effect.

Climb or Descent. The indications are presented by a vertical displacement of the outline, i.e., the rate of climb conditions are changed into electrical quantities and applied as bias to the vertical deflector plates of the tube.

Bank and Turn. Rheostats are connected to the usual instruments to obtain conversion to electrical quantities. Deliberate distortion of the outline could be used to indicate over or under banking. One way would be to alter the bias of a pentode tube and so cause the wings of the outline to become of unequal length.

Landing. The position of the outline relative to the screen could be equal to the position of the real plane relative to a Lorenz-type beam.

Height. A radio altimeter, working on the reflection principle, would enable a spot to be exhibited at the correct point of the height scale.

Compass Bearing. This is shown

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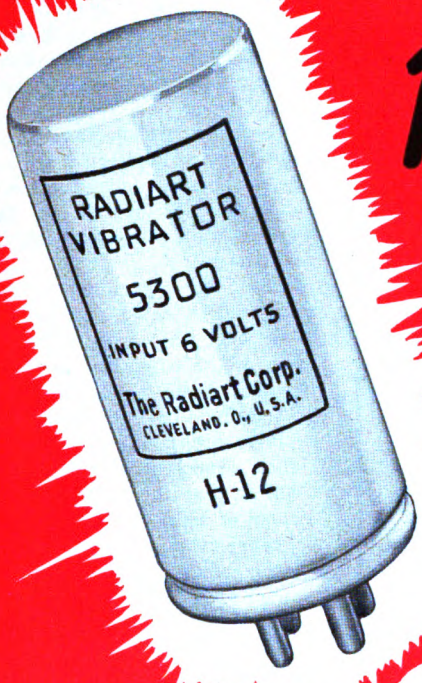

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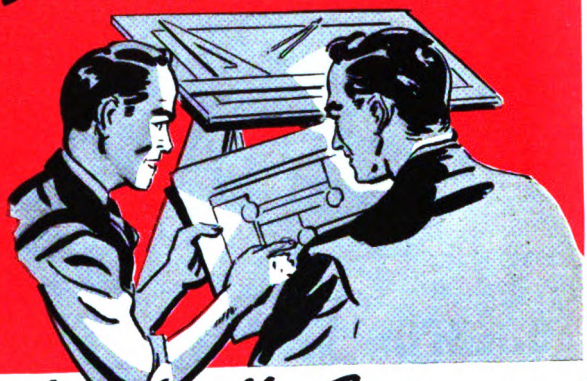

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Since each RADIART VIBRATOR is individually engineered all additional attachments for electrical grounding or for holding the vibrator in the socket are eliminated.

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RADIART VIBRATORS are engineered for the individual requirements of each circuit application, taking into consideration every operating essential such as frequency, current carrying capacity, points and reads properly tuned for transformer-buffer circuit requirements.

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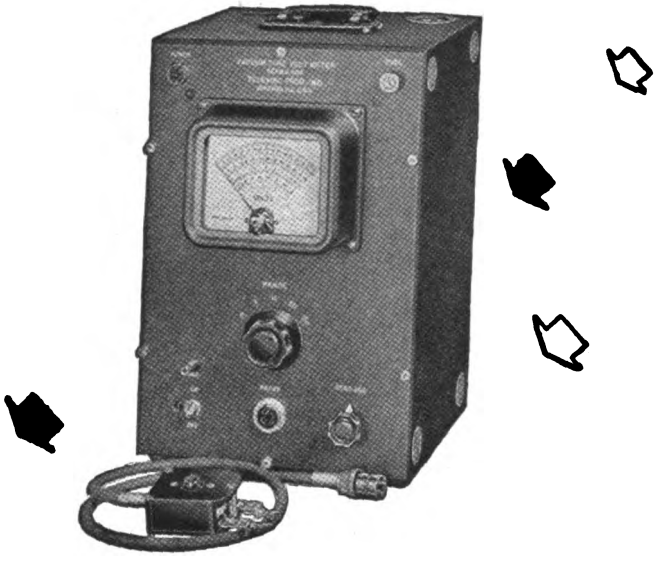

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A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable. IMPORTANT WAR TIME DEVELOPMENTS ARE AVAILABLE FOR THE FIRST TIME IN THE FOLLOWING FEATURES:—

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural.); sub-chassis is ⅛" and spaced off the panel by stubs to simplify servicing; all components are fastened to sub-chassis.

ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shortening of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usuable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the field. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts ac. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago.

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in a similar way to he spot on the outer edge positioned to repeat t of the compass in the t craft.

These last two spots same beam as used to t line, since even under tions the c-r tube is worked so hard as und conditions.

Icing. Here, a simp suggested to increase t of the spot when tracin edges of the wings and it when tracing the low

Gasoline. To indicat supplies are running l signer proposes to m beam so that the outlin instead of solid.

Perhaps the most imp of the whole instrume method of obtaining the the plane on the screen. would be to use television and to scan a cut-out o chine, but the designer pr other method, under the the outline would be bri more distinct. The metho essentially of motor-drive terposed between a series cells and lamps. Six cams gested, two each for the ou wing flaps and the retrac dercarriage, the last two a on the outline at the requir

The outputs of the phot amplified to produce the voltages necessary for ap to the deflector plates of tube.

• • •

Aviation's Electronic Requirements

By D. W. RENTZEL, *Presi*
Aeronautical Radio, Inc.
Washington, D. C.

COME OF AGE as a major m transportation by the impe the war, aviation is in a posi dominate the coming age. ever, the prominent limitati safe, on-schedule flights ar able of solution only through tronic means. At present in th ation industry electronic de ments are trailing some o other elements of air transp tion. Solutions to many of problems are in the offing; all

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INCREDIBLE SALVAGE

The Case of the Flying Gull . . .

During the storm season of 1942, *The Flying Gull* ran into heavy seas in the Gulf of Mexico.* Running before a terrific wind, she all but made port. Then, just as she was putting about near Hunter's Point, she shipped a gigantic wave and foundered. All hands were saved. But *The Flying Gull* rested in eight fathoms of Gulf water.

Salvage operations were started. Later in 1942, when The Flying Gull was in the dock and her electrical equipment ripped out, an amazing thing occurred. George Long, of The Harris Salvage and Drydock Company of Galveston, put the Thermador transformer equipment on a shelf in the sunshine—mentally assigning it to the scrap metal drive. Three days later, out of curiosity, he hooked the transformers onto a testing bench and flipped on the current. To his amazement, they still showed signs of life. He then ran standard tests. To his further astonishment, all twelve of the transformers were not only working—they were working perfectly.

Harvy Stark, owner of the boat, had already ordered a complete new set of transformers from Thermador. He cancelled the re-order. And today The Flying Gull sails with her original Thermador transformers. Not designed for the briny deep—but they could take it!

Such stories of plus performance are not accidents, for Thermador transformers are built to perform beyond normal expectations. They are completely manufactured—not just assembled—under one roof on a vast array of modern precision equipment. They are made *only* from the finest materials, engineered by men of broad experience. The result is not alone quality but *quality in quantity*. If that meets your specifications, better discuss transformers with Thermador.

THERMADOR TRANSFORMERS

DEFEAT HEAT • COLD • HUMIDITY

"SEVEN LEAGUES AHEAD"

An actual case history from Thermador files; however names, dates, and location have been altered.* **Buy MORE War Bonds.

THERMADOR ELECTRICAL MANUFACTURING COMPANY

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it is folly to put the plow in front of the oxen . . .

. . . and it is equally bungling to use a cheap substitute for Macallen Mica. Not many do, but every once in a while somebody has to learn from experience that trifling with insulation can be a disastrous experiment. The fact of dependability in Macallen Mica has been known to experts for more than 50 years.

When you think of MICA think of MACALLEN

the Macallen Company

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remains for some is to be put into commercial form.

Obstacle Indicator

Increased flying speeds require a warning to the pilot of obstructions such as mountains, buildings (This paper was prepared prior to the Empire State Building disaster.—Ed. note) or other aircraft. Such equipment should take advantage of transmitters on the obstacle or other aircraft. A cone of ±15 degrees from the plane's center line should be scanned continuously, and it should be possible to explore a wider angle at will. The instrument should give indications of distance, position, elevation relative to the plane, and sight or sound alarm if the aircraft comes within a preset distance of the obstacle.

The obstacle indicator should have a range of approximately twenty miles (at current transport flying speeds this range allows only four minutes for avoiding obstructions). Its weight should be held within 50 pounds, 90 pounds if the instrument also serves as radio altimeter. Ground beacons could be used to reduce the weight and power of aircraft installations.

Radio Altimeter

Preferably operating in conjunction with the obstacle indicator, the radio altimeter should have a vertical range of 40,000 feet, the elevation being indicated on low and high altitude scales. Its accuracy should be within three percent and its stability within 30 feet over a 15 minute period. There should be a button for service test indications. The altimeter indication might well be combined with the indication of a ranging instrument.

One important application of the radio altimeter is in isobar flying. Instead of flying the most direct course, transports fly on long hops with the motion of the air masses thus flying the course giving the shortest flight time.

In addition to weather reports indicating the positions of high pressure areas which rotate clockwise and low pressure masses which rotate counter-clockwise (in the northern hemisphere) from

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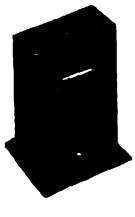
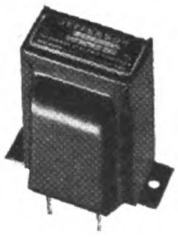
And there is more to producing top-performance transformers than assembling coils, cores, etc. in an enclosing case.

Correct use of engineering—years of experience—control of quality and manufacture in everyday large scale production—and the selection of the appropriate type and design for each particular requirement—are all essential to successful operation.

The hundreds of thousands of transformers regularly produced—are ample proof that leading manufacturers of equipment in electronic, lighting, radio and similar fields prefer Jefferson Electric Transformers. Recommendations concerning transformers made by the Jefferson Electric engineering staff can save time for you—and insure the performance you desire. JEFFERSON ELECTRIC COMPANY, Bellwood (Suburb of Chicago), Illinois. In Canada: Canadian Jefferson Electric Co. Ltd., 384 Pape St., Toronto, Ont.



JEFFERSON ELECTRIC



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In standard grades—or special high silicons to meet specific requirements—Follansbee punching and shearing quality reaches the ultimate permitted by the silicon content . . . width and gauge are to the closest tolerances . . . surface finishes and stacking factors meet exacting specifications.

The rigid control necessary in the production of high quality Silicon Steels coincides perfectly with the practices followed by Follansbee through generations of fine steelmaking. When placing your next order for Electrical Sheets or Strip—check with Follansbee.

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which the navigator can chose the course, the navigator can compare the indications of the radio and barometric altimeters and thus observe his position relative to high and low pressure areas.

Experience with radio altimeters as landing instruments has indicated that obstructions on the path of approach to the runway, while not high enough to interfere with the glide path, produce excessive needle flutter in the altimeter.

Automatic Position Reporting

With increased aircraft traffic it is necessary to have available continuous data on plane positions. There is need for automatic equipment that will identify and give altitude, azimuth and range of all aircraft within the control area and duplicate this information to all interested parties. It would be advantageous if there could be superimposed on the indications of aircraft positions the locations of such navigational hindrances as thunderstorms.

Written Communications to Aircraft

The volume of information required in airline aircraft necessitates a means of sending written communications to aircraft, either by facsimile or radio teletype. Such an installation would free the plane personnel from the necessity of giving their attention to routine messages as such communications were transmitted.

The aircraft printer should be of the page type rather than of the tape type to eliminate the necessity of scanning for information, and should not weigh in excess of 25 pounds exclusive of the receiver. Paper should feed freely to avoid jamming during unattended periods. There should be several selectable channels, but transmission should be held to a narrow bandwidth. A keyboard and transmitter aboard the plane is not necessary, but such units should be adaptable to the receiver-printer.

Electrical Power on Aircraft

Equipment should operate from the normal power system of the plane. At the present most airline and private aircraft utilize the 12

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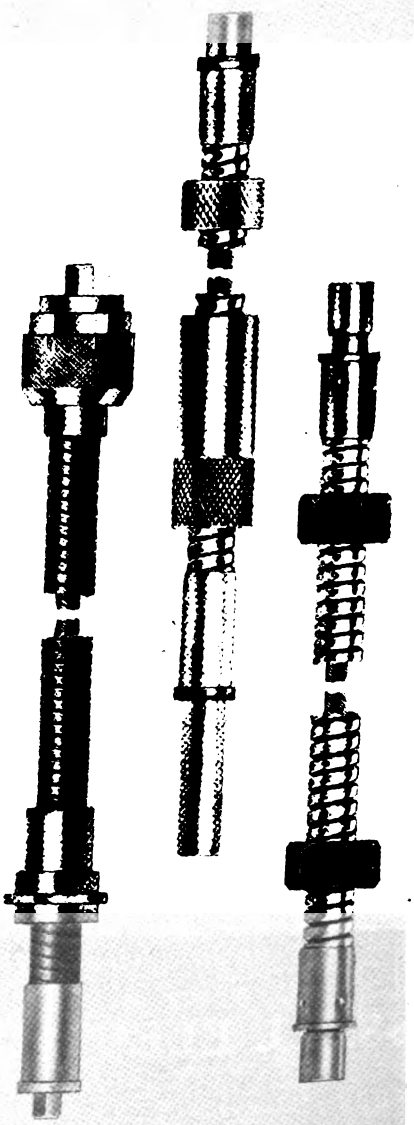

Operation of remote control flexible shafts must be smooth and easy, free from any tendency to "jump". That's why the greatest care is taken in winding Walker-Turner Remote Control Shafting —to eliminate "back-lash"—to hold torsional deflection to a minimum in either direction of rotation—to keep internal friction low.

Result: in many applications, the same sensitive control is achieved with Walker-Turner Flexible Shafting as with a direct connection. Whether you need flexible shafting for remote control, push-pull or power transmission, you'll find careful design and manufacture, and high performance, characteristic of every type of Walker-Turner Flexible Shafting. Write today for our latest catalog.

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volt, ... craft utilize ... tem. It appears, ... made by Aeronautical ... half of the airlines, t... volt d-c system will be ... after the war, althou... ages at 400 cycles may ...

Air Borne Equi...

Equipment carried ... plane must be kept to a ... imum, 200 pounds see... able figure for all radi... in the ship. Such ... units as marker rece... are in use only a minut... the flight time should ... with other services. T... of aircraft communi... navigation channels at ... gion in the radio spectr... lot toward simplifying ... sign and utilization pro...

For international ai... operation supplemental ... will be necessary. The ... will not be interested ... available radio services. ... turers will do well to de... age units that can be ad... need grows, each buildi... circuits present in the ... installed units.

• • •

Medical Probe

By ROBERT E. RIC...
Auburn, N. Y.

IN THE MEDICAL FIELD of ... there is a need for severa... struments the develop... which need no longer ... capped by lack of the desi... oscillators, transmitters, ... ceivers. Work was begu... such instrument prior to t...

The instrument, desig... the R-K Probe, was origi... signed for two purposes: ... indicate irregularities of ... organs under the skin; an... indicate the size and place... large organs of the body. ... ity of such an instrument ... could be highly portable, lie... amining patients whose c... excludes moving them to ... fluorscope installations.

The instrument consist... transmitter, receiver, indica... a power supply for operati...

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ONE PURPOSE ... *the improvement of capacitors*

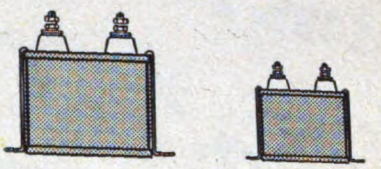
C-D never relaxes in its determination to improve capacitor design and to develop new and better materials and processes of manufacture. The C-D Type TJ series is typical of improved capacitor engineering.

Where a lot of capacitance must be packed into little space, there is no better capacitor for high voltage filter applications than the C-D Type TJ containing the Dykanol impregnant.

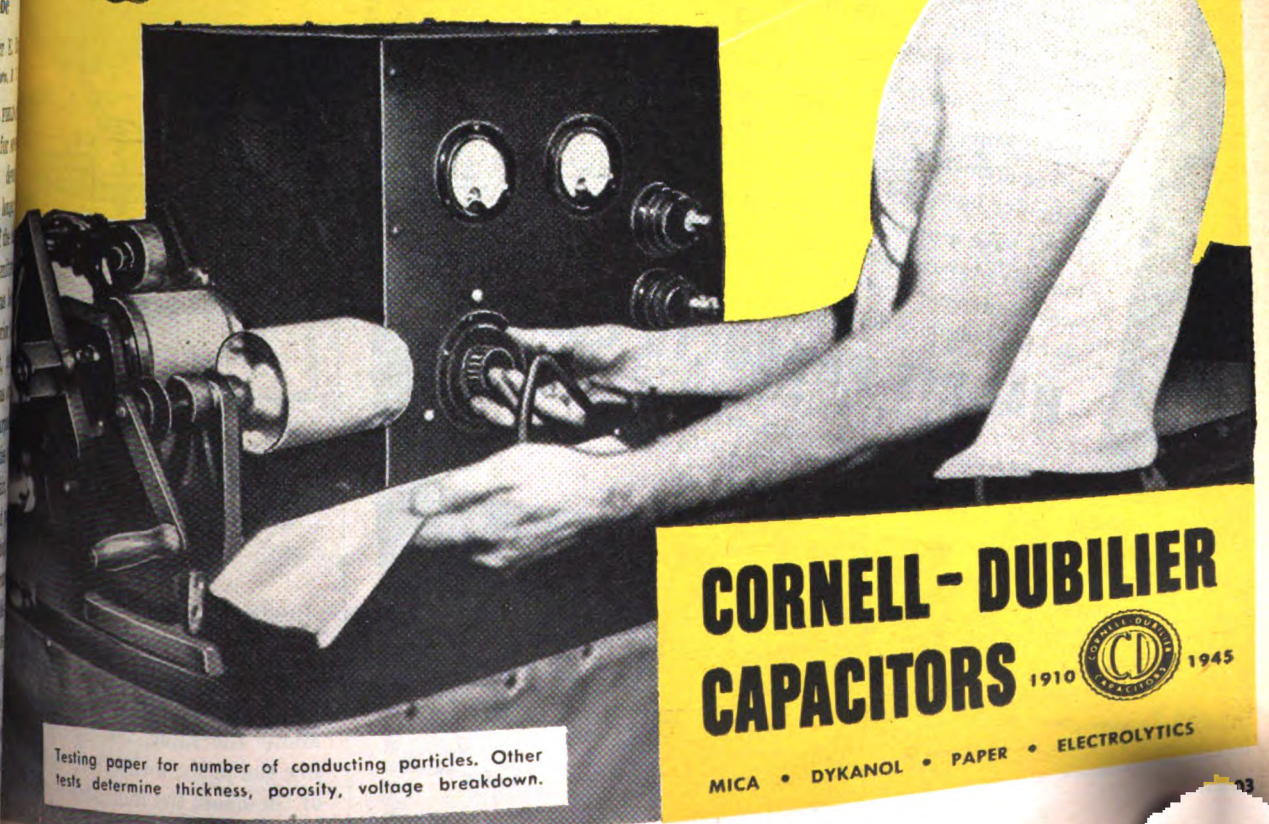
Dykanol "G", due to its chemical stability, allows operation at higher temperatures. It also permits the use of maximum paper thickness for a given size container, with a high factor of safety due to low voltage stress. Insulation resistance is five or more times as high as in capacitors using organic oil impregnants. On the larger sizes of the Type TJ series, the sturdy porcelain terminals withstand extremes of heat and cold and are practically unbreakable.

Look to Cornell-Dubilier for the extra quality and dependability that is engineered into every capacitor — the result of C-D's 35 years of capacitor specialization. Cornell-Dubilier Electric Corporation, South Plainfield, N. J. Other plants at New Bedford, Brookline, Worcester, Mass. and Providence, R. I.

Comparative size of capacitors for same voltage stress using two types of impregnants.



MINERAL OIL C-D DYKANOL



Testing paper for number of conducting particles. Other tests determine thickness, porosity, voltage breakdown.

CORNELL-DUBILIER CAPACITORS 1910 1945

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ABSORB JOLTS *and* SHOCKS
Protect
DELICATE INSTRUMENTS

Duflex mounts, through shear-stressed rubber, protect sensitive apparatus from shock and vibration, enabling it to maintain accuracy and prolonging the life of the apparatus.

Duflex mounts are light in weight yet sturdy and in the case of instruments, radios, electrical control equipment, etc., they provide an effective suspension capable of preventing the transmission of vibrations or shocks.

Duflex mounts are made in accordance with the Army-Navy standards to suit any requirements as to weight, frequency, deflection or operating conditions.

If you have a problem send it in; our engineers may already have the answer, if not they will gladly work with your engineers on solving it. Send for our free Bulletin Series 1022 on Duflex mounts today.

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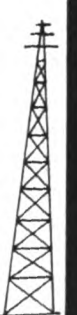
GENERAL MOTORS BUILDING, DETROIT



house current. A
shown in Fig. 1, altho
satisfactory, did ind
rection in which to p

Basic Princi

The principle of t
simple. An electroma
set up about one inch
tion of the body to
Assuming the air and
of the medium under
as a fairly constant
the probe were held a
from the body irregul
be detected as a chan
tric.

For example, the pro
inch from a reference
body—such as the fore
rests close to the body
justed for a set indi
probe is then moved in

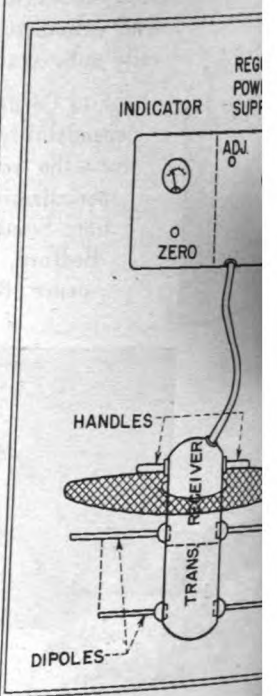


Fig. 1—Experimental model Probe used to diagnose phys normalities. Hand probe use amine patient contained transm receiver

direction of the heart until
deflection is noted on the in
By one's moving the prob
rough oval, the reading
about the same, but in one
ing the probe away from the
of the heart the indicator ret
normal. If the operator in

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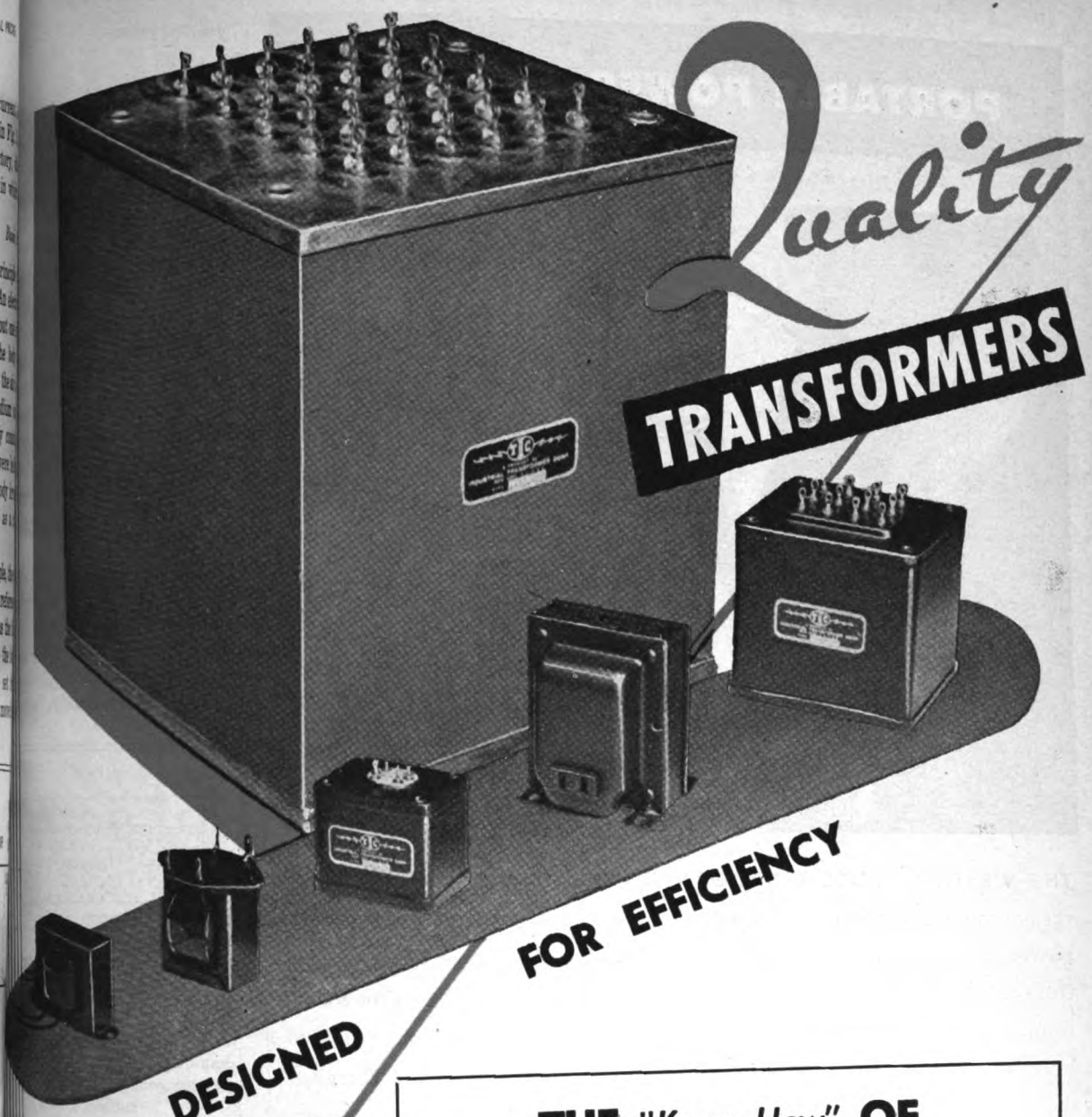

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THE *"Know-How"* OF TRANSFORMERS

. . . ITC combines years of experience in the field, with leadership in the scientific design of every type of transformer for every application . . . to bring you *better* transformers.

. . . The trained, skilled engineers who design ITC TRANSFORMERS are ready to aid you with your individual transformer problems.

. . . For dependable service now . . . and in the future, be sure to use and specify ITC TRANSFORMERS.

. . . Your inquiries are invited.

INDUSTRIAL TRANSFORMER CORP.
2540 BELMONT AVENUE, NEW YORK, N. Y.

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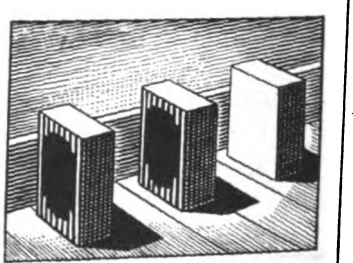
PORTABLE POWER PROBLEMS

THIS MONTH — WESTINGHOUSE VIBROGRAPH

THE WESTINGHOUSE VIBROGRAPH—an accurate instrument for measuring and recording vibrations—is one of many time-saving devices powered by Burgess Industrial Batteries. Where sensitive test and control equipment is regularly employed, engineers specify Burgess for maximum quality and service. The complete Burgess Industrial Battery line is built to meet every standard commercial requirement. Your Burgess distributor can fill your needs today—write for his name and address.

BURGESS IS FIRST CHOICE OF 2 OUT OF 3 in recent nation-wide survey of manufacturer electronic engineers. If you have a special battery application, Burgess engineers are equipped to develop the type you need.
Burgess Battery Company, Freeport, Ill.



BURGESS BATTERIES

REMEMBER THE WAR CHEST—GIVE TODAY!

VOTED *FIRST* BY ELECTRONIC ENGINEERS

paper betwe
probe and attaches
to the probe, a rough
heart can be quickly
Similarly the probe
to locate bone irregul
eign bodies in the pa
Figure 2 is a wood
stone and a piece
bedded between grave
The probe is adjust
point A for a refere
point B the meter show
flection, while at poin
cator reading rises.

Experimental M

The preliminary w
first model indicated
extremely sensitive to
the medium being ex
viding the surface lay
form. Unfortunately,

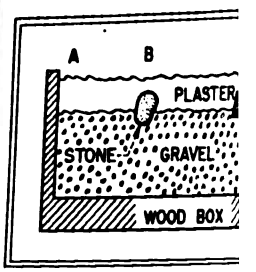


Fig. 2—Laboratory dummy that probe will indicate i under the surface. Stone simulate foreign particles e subcutaneous tissue but hid sufferer's skin

mc the electromagnetic
too sensitive to disc
within several feet of th
under examination. Also
housing both transmitte
ceiver was heavy and cu
Instabilities indicated a
tuning of the transmitte
ceiver and provision for
ing a more constant field.

The second model was
to work at a much hig
quency with a more dire
tenna system. A single di
used for the transmitte
single dipole for the recei
transmitter and receiver w
tained in the indicator hou
connected to the probe by
line. This resulted in
smaller probe, a major i
ment. The housing of th
was drilled and tapped a

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u're in good company . . .

in Southern ew England

matter where you go in industrial Southern England, it won't be long before you come n the plant of a well-known manufacturer.

example, in this section of Connecticut, nation-famous typewriters, locks, firearms, silver-e, brushes, tools, safety razors, rugs, vacuum tles, aviation engines and propellers, rubber ds, shaving cream, soap and skin lotion, as ll as many other products, are manufactured.

ery one of these products has a name as familiar your own. Many of them had their beginnings re. Others have come because of conditions fav-able to manufacturing . . . generations of skilled aftsmen; abundant power; fair taxes; industri-ly-minded banking; State and local government at grew up with industry and understands its roblems.

But that is only part of the story.

Southern New England lies in the heart of the world's richest, most-highly concentrated market.

Within a radius of 500 miles live 58,000,000 peo-ple to absorb not only Southern New England's consumers' goods but her producers' commodities —the tools and parts that go into other industries.

And because no part of Southern New England is more than 125 miles from tidewater and the great ports leading to foreign markets, manufacturers locating here will be at the threshold of the huge overseas trade that will develop during the great era of peacetime commerce ahead.

Southern New England offers better personal living, too, for it abounds in charming residential communities with good schools, churches, lakes, hills and sandy beaches—all close by.

In planning your tomorrow, don't overlook Southern New England—perfect for your new or expanding business . . . and for your all-around enjoyment of life.

An industrial booklet in full color, "Southern New England for Tomorrow's Industry", is yours for the asking. Write to P. E. Benjamin, Manager of Industrial Development, The New Haven Railroad, 80 Federal Street, Boston 10, Mass.

This is one of a series of advertisements presenting the industrial advantages of Southern New England.

THE NEW HAVEN R.R.

Serving **SOUTHERN NEW ENGLAND** *with a network of rail and highway transportation that puts every manufacturer* "ON THE MAIN LINE".

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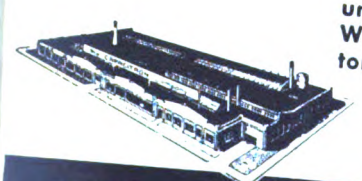
Quality . . .

A Success Secret of
CAPACITRONS

The Capacitron reputation for progressive design, superior craftsmanship and dependable service is backed by a continuous research program covering every capacitor manufacturing operation. No Capacitron production process is ever given a chance to become "standard procedure"—it is always an engineering project—always open for immediate improvement. Through this system of *method control* has come unquestioned leadership for Capacitron Oil, Wax and Electrolytic Capacitors . . . our customers call it Quality.



Telephone VAN Buren 3322

The CAPACITRON Company
849 North Kedzie Ave., Chicago 51, Illinois

points for reflectors to a beam. These experim second model and its d ray were never completed

Results of Experi

From the work done ing observations can be

SIZE-WEIGHT: A probe signed to fit in the pa hand and light enough dled by one hand. A were made on the front p instrument proper by hand.

INTERFERENCE: Two sepa lems were encountered he terference due to organi such as the operator, and ference from surroundin of which metal caused th difficulty. The use of a m tive antenna, lower powe sensitivity adjustment on ceiver, would reduce inte

SENSITIVITY: The sensit the receiver, and stability transmitter were peculia lems. An instable transmit critical to adjust and made t sensitive probe useless.

BALANCED ELECTROMA FIELD: This problem was a is the major one and has n do with the phase relatio mentioned previously. A bal obtained between the portion field absorbed by the mediu that reflected to the receiv tenna in the initial adjustm the probe at its reference Variations from the referenc justment activate the indicato tion of the instrument.

Further Study

The second model gave a p output of seven watts from transmitter; considerable of power was lost in the coaxial to the probe. The amount of po and the required sensitivity such an instrument must be de mined from further study.

A lower-power probe using wave guide in duplex as transm ter and receiver may solve some the interference problems of earli probes.

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For Electronic Circuits ...one-piece HYDENT connectors assure connections of high electrical efficiency and stability...They cut costs up to 50%, too!

There's never any doubt about either stability or *electrical efficiency* of a HYDENT connection. That's why Federal Manufacturing & Engineering Corp. of Brooklyn, N. Y., selected Burndy HYLUGS for the wiring harness of this signal generator. Built to meet the exacting specifications of military service, the manufacturer could take no chances on faulty connections in this equipment. *HYDENT* connectors are virtually *coined* to the conductors by the Burndy HYPRESS, in one quick operation, thus eliminating costly and messy operations involved in soldering. In addition, the finished connections are easy to inspect. Why not investigate this modern, economical connecting method today. Write to... Burndy Engineering Co., Inc., 107-L Bruckner Blvd., New York 54, N. Y.

Headquarters for CONNECTORS

Burndy

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NEWS OF THE INDUSTRY

New RTPB officials; receiver licensees; standards; radar display; meeting schedule; news of Washington; FCC actions; industrial activities; people, and awards

Science Search: Man and Material

BECAUSE OF A PREDICTED shortage in scientifically talented people with corresponding training, Dr. Vannevar Bush, director of OSRD (Office of Scientific Research and Development) has recently made some proposals in a report to the President, a report called "Science, the Endless Frontier." In it he suggests that the armed services be culled for people who should continue their scientific education as soon as possible. This would plug up holes in the ranks of science caused by what he describes as the radical way educational activities in science were suspended during the war.

He also points out that higher education has heretofore been available only for those who could afford it and whether they had talent or not. His feeling is that talented individuals in every segment of society should not be wasted by lack of education.

Specifically, he advocates the establishment of a National Research Foundation consisting of nine members to be selected by the President and responsible to him. They would be divided into five sections covering medical research, natural sciences, national defense, scientific personnel and education, and publications and scientific collaboration. He sets the prospective cost at $33,000,000 at the outset with a possible gradual rise thereafter.

Meanwhile, in Germany, technical specialists are searching through the files of German scientists to be sure we are fully abreast of all types of scientific endeavor. In the communication field, nine specialists were reported by the Foreign Economic Administrator as having been active in investigations. The group included: John A. Parrott, AT&T; Pierre Mertz and John A. Townsend, Bell Labs; Todos M. Odarenko, Federal Telephone & Radio Laboratories; C. W. Hansell, RCA; Frederick E. Henderson and Roland H. McCarthy, Western Electric Co.; Charles M. Banca, RCA, and C. B. Horsley, Harvey-Wells Electronics.

Hams in Again

AN ANNOUNCEMENT by FCC permits those amateur radio operators who are in good standing to return to the air at once, operating in the 112-115.5 mc band until November 15. The shift to 144-148 mc will follow.

Naval Research

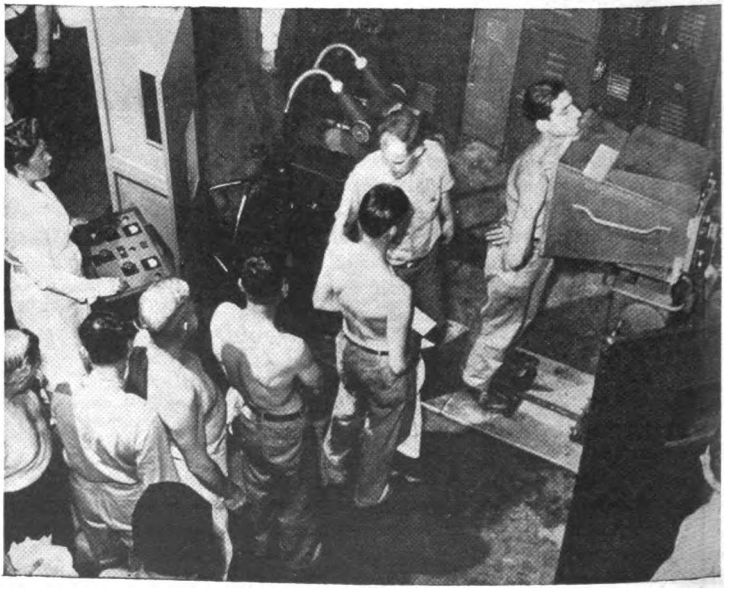
BRINGING TOP-FLIGHT technical talent into close contact with fleet operating and maintenance problems is one of the objectives of a recent reorganization of the Naval Research Laboratory. War experience has dictated the changes.

Four new scientific divisions have been set up by Rear Admiral A. H. Van Keuren, director of the Naval Research Laboratory, to cover activities which were formerly contained in a single radio division under Dr. A. Hoyt Taylor of Chicago, Ill. Dr. Taylor now becomes chief consultant and chief coordinator for electronics. Heads for the new divisions are as follows: fire control division—Dr. Robert M. Page,

Admiral Alex H. Van Keuren

Dr. A. Hoyt Taylor

Dr. Robert M. Page



Electronic controls automatically regulate exposure time in this chest x-ray operation at McNulty Shipyards in Brooklyn, N. Y. Developed by North American Philips Co., this particular unit handles plant workers in rapid-fire order taking x-ray images on 70 mm film. Equipment was provided by the U. S. Public Health Service

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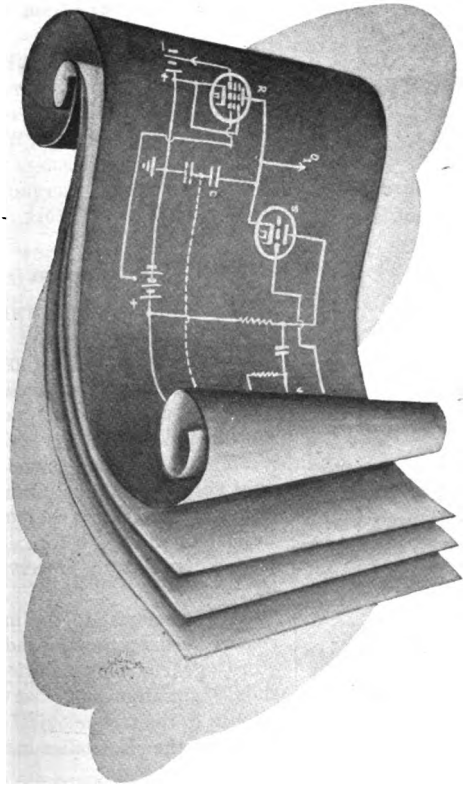
Specialized Knowledge and Equipment for UHF DESIGN



● The phenomena encountered in the UHF field are in many cases so decidedly different from those true of lower frequencies that many manufacturers find themselves in urgent need of specialized UHF knowledge, in order to develop equipment that will handle certain specific conditions.

● Since we are specialists in UHF engineering, we are equipped not only to render technical advice, but also to follow through in the actual production of equipment in our shops.

● Of necessity, during the war period, our efforts have been concentrated largely on Army and Navy work. Now that peace is with us, we have adequate time to devote to civilian requirements. We invite discussion of any problems you may have in the UHF field.

U H F

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists in The Development of UHF Equipment
and in The Manufacture of UHF Antennas

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for all Leading Makes of
TRANSFORMERS

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It's simpler, faster to get your transformer needs from this one central source. Here, under one roof, are *all the leading makes, in all the wanted types:*

Power • Adjustable • Voltage Regulating
Step-up and Step-down • Plate and Filament
Audio Input • Interstage and Output • Modulation
Driver • Microphone, Line and Mixing Transformers
Filter and Swinging Chokes • Audio Reactors
Fluorescent Lighting Ballasts

Large and varied stocks are maintained for *rush service.* Close contact with manufacturers expedites procurement. This complete service saves time and work. That's why thousands call ALLIED First!

Helpful **BUYING GUIDE** Available on Request Write for it!

WRITE, WIRE, OR PHONE HAYMARKET 6800
for Everything in Radio and Electronics

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SUPPLIERS OF ELECTRONIC PARTS AND EQUIPMENT TO INDUSTRIAL AMERICA
Electronic Tubes, Rectifiers, Power Supplies, Intercommunicating Systems, Sound Systems, Photo-Cell Equipment, Batteries, Chargers, Converters, Generators, Supplies for Resistance Welders, Fuses, Test Instruments, Meters, Broadcast Station Equipment, Relays, Condensers, Capacitors, Resistors, Rheostats, Transformers, Switches, Coaxial Cable, Wire, Soldering Irons, Microphones, Speakers, Technical Books, etc.

Superintendent, St. Paul, Minn.; special electronics research and development division—John M. Miller, Hanover, Pa.; ship-shore radio division—L. A. Gebhard, Buffalo, N. Y.; airborne electronics—R. A. Gordon, Hyattsville, Md.

RTPB Election

FOR THE TERM running from Oct. 1, 1945 to Sept. 30, 1946, the administrative committee of RTPB (Radio Technical Planning Board) has elected the following officials: chairman, Haraden Pratt, Mackay Radio

Haraden Pratt

& Telegraph Co., New York; vice chairman, Howard S. Frazier, National Association of Broadcasters, Washington; treasurer, Will Baltin, Television Broadcasters Association, New York; secretary, W. H. Crew, IRE, New York.

Radio War Museum

THE ADVERTISING COMMITTEE of RMA headed by John S. Garceau, Fort Wayne, Ind., is proposing the establishment of a national war museum to exhibit radio and radar equipment.

Members of the committee feel that action should be taken shortly. Otherwise electronic equipment may be lost to salvage before an organized movement to preserve it can be made.

As a memorial to the important role of heroic radio and radar operators, gear from historic battles should simultaneously serve as a tribute to the technological achievements of the electronics industry.

New Receiver Makers

LICENSES have been issued by RCA to permit receiver manufacturing by a number of new concerns. The present total is 105, a figure which can be compared with the 54 manu-

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Now—a silicone varnish that cures at 300°F

DC 996 VARNISH

DOW CORNING
SILICONES

Dow Corning 996 is an electrical impregnating varnish for low temperature baking.

Dow Corning 996 was developed to provide manufacturers of new equipment and rewinders of old equipment with a heat resistant, waterproof silicone varnish which can be cured at temperatures obtainable in ovens now used for curing organic insulating varnishes.

Dow Corning 996 is used as the dipping or impregnating varnish for equipment wound with typical silicone insulation components. These include Fiberglas cloth, tape and sleeving varnished with DC 993; silicone bonded mica-Fiberglas for ground insulation; silicone bonded Fiberglas served magnet wire; silicone-Fiberglas laminated coil separators and slot sticks, and Silastic* coated lead wire.

Electrical equipment, wound with silicone insulating components and sealed by impregnating with DC 996, will have the high order of thermal stability and retention of waterproofness characteristic of silicone insulation.

Dow Corning 996 thus enables all types of electrical shops to realize the advantages of silicone insulation. It is recommended for use in equipment which is to be operated at temperatures up to 175°C. (347°F.). For higher operating temperatures, or extremely severe service conditions, DC 993 should be used throughout. The same methods of dipping, spraying, or vacuum-pressure impregnating that are used for applying conventional organic varnishes can be used with DC 996.

PROPERTIES—Dow Corning 996 is furnished as a 50 per cent by weight solution in an aromatic solvent and has a viscosity of 2 to 5 poises. In this consistency DC 996 is suitable for impregnating electrical equipment. It can be reduced to any desired viscosity with aromatic naphtha.

Dow Corning 996, when coated on metal, air dries to a slightly tacky, soft film. Baking the coated panel at 150°C. (302°F.) for a period of four hours will cure the coating to a non-flowing, tack-free, flexible film. DC 996 has ample heat stability for continuous use at temperatures as high as 175°C. or for intermittent use at higher temperatures.

ELECTRICAL PROPERTIES OF DC 996—(measured on coated panels at 25°C. and 50% relative humidity.)

Dielectric Strength, volts per mil	1500 to 2000
Dielectric Constant, at 1000 cycles	3.0
Power Factor, at 1000 cycles	0.7%

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
NEW YORK OFFICE: EMPIRE STATE BUILDING

DISTRIBUTED BY

Electrical Specialty Co.	San Francisco
Prehler Electrical Insulation Company	Chicago
Insulation Manufacturers Corporation	Chicago
Insulation and Wires, Incorporated	St. Louis
Mica Insulator Company	Schenectady
National Electric Coil Company	Columbus
Westinghouse Electric Corporation Insulation Section, Micarta Division	Trafford, Penna.

* Trade name for Dow Corning Silicone Rubber

Dow Corning
FIRST IN SILICONES

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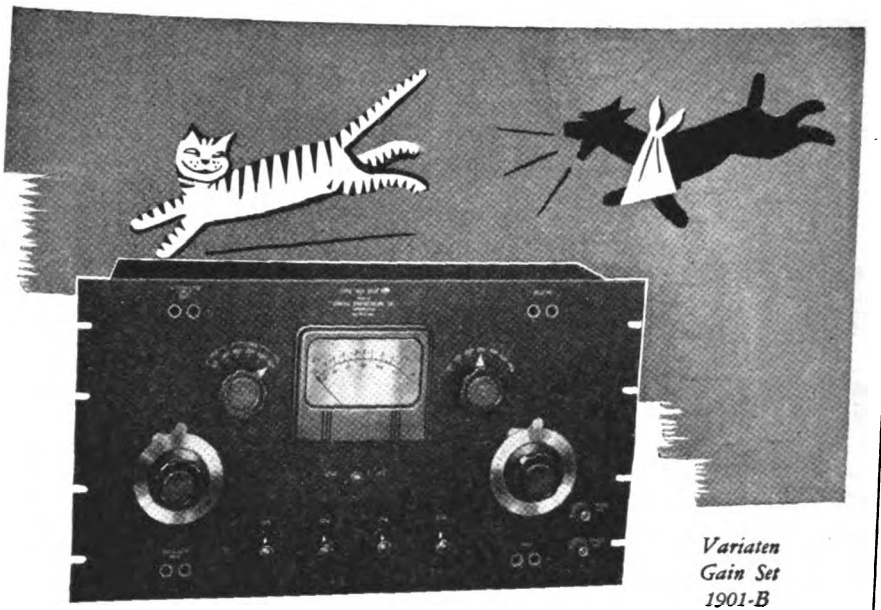

Variaten Gain Set 1901-B

As necessary to perfect Amplifier performance as the fourth leg to a dog!

You can't have perfect performance in amplifying or other speech transmission without knowing the efficiency and performance of each unit in the installation.

With a Variaten Gain Set you can (1) measure the total amplification of an amplifier; (2) measure the gain at all frequencies to determine whether there is discrimination against any part of the frequency spectrum; (3) measure the power output of any amplifier; (4) measure frequency response of transmission lines in absolute quantities; (5) check all control equipment—in fact, quickly make a quantitative analysis of any part of the audio frequency spectrum.

Unvarying accuracy is all-important. Variaten Gain Set, Type 1901-B (shown above) has a flat frequency characteristic of 0 to 20 kilocycles, and leakage is *guaranteed to be less than 1/10th db.* (Measurements have been made at frequencies as high as 100 kilocycles with practically no error.)

Variaten Gain Set 1901-B is equipped with both send and receive impedance matching controls for *both* Straight T and Balanced H circuits. This dependably accurate instrument can be supplied with either one or two meters.

Write today for complete data on Type 1901-B and other Variaten Gain Sets.

Other Variaten products—*Attenuators, Mixers, Resistors, Matching Pads and other precision sound equipment meet the most exacting specifications. Catalog on request.*

VARIATEN

CINEMA ENGINEERING CO.

Established 1935 • Burbank • California

facturers who wer
the war.

The new license
stal Products Co., I
Electrical Researcl
Angeles, Calif.; I
Mfg. Co., Kansas C
Corp., Los Angeles,
Scientific Producti
Precise Developmer
Premier Tool & In
New York, N. Y.;
Co., Los Angeles
Energy Radio & T
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Electronic & Mfg.
N. Y.; Tech-Master
New York, N. Y.;
gineering Co., Los
Whiting & Davis
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formed as a result o
by the Radio Parts I
dinating Committee.

Merged in the new
the Radio Parts Indu
Trade Show and the

Radio officer graduates o
Maritime Service Radio T
tion, Gallups Island, Bos
who have lost their lives
ice of their country are n
by this dramatic monumen
is being inspected by Lt. C
W. Larsen, administrative o
station; Commodore Telfa
Commandant of the U. S.
Service; and J. A. Clark,
Officer of the stati

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IT'S THE *KNOW HOW* THAT MAKES THE DIFFERENCE

From the same basic ingredients can come many different results, some excellent, some, . . . well not so good. Whether it's cakes or regulators, it's the "KNOW HOW" that counts.

The engineering staff of Sorensen and Company, Inc. have developed a new idea in voltage regulators. Models 1K, 2K, and 3K, will meet 90% of all the requirements and applications of voltage regulators.

The 60 cycle models 1K and 2K, cover power requirements from 100 to 2000 watts. The 400 cycle model, 3K handles powers from 50 to 500 watts—(they are not resonant type regulators . . . automatic voltage control is accomplished by electronic means). Voltage control stability is better than plus or minus ¾ of 1% for input variations of from 90 to 130 volts.

The 60 cycle models are constructed for rack or cabinet. The 400 cycle model, 3K, is in shock mounts. All the regulators are outstanding because frequency variation does not affect the regulation factor.

Sorensen and Company, Inc. likewise offers voltage adjustable transformers in ratings from 500 V.A. to 1500 V.A. These models known as INCREVOLT controls are capable of providing voltage in increments as small as ONE TENTH VOLT, in a range of from 0 - 130 volts.

We are the only source for lightweight aircraft transformers which feature the Fosterite and oil filled units.

SORENSEN & COMPANY, INC.
STAMFORD, CONN.

AIRBORNE ELECTRONICS

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Model 636 Dynamic* Tube Tester

With Built In Rotary Tube Chart

Tops in design and performance including the latest Jackson patented switching circuits.

Modern in every feature of construction, appearance and operation.

Complete with every valuable feature. Up to date for all newest tube types.

SPECIFICATIONS

"Dynamic" Method of Test—Makes a better test on every tube. The "Dynamic" method is more accurate, frequently finding "poor" tubes which might pass for "good" in ordinary testers.

Tests All Tubes—All of the popular receiving types and television amplifiers, including *Bamtams—Loctals—Single Ended—High Voltage Filament Types and Miniatures*. Provision for many more. The tester is protected against obsolescence in every possible feature.

Roll Chart tube index—simplifies correct settings.

Full Range Filament Selection—marked directly in volts.

• • •

Bench Model 636-B (illustrated) is installed in welded steel cabinet. This instrument is also furnished (portable model 636) in a French grey leatherette case with removable lid—matched in dimensions and finish to other testing instruments in the Jackson line. It can be assembled with them in the Jackson Service Lab. Buy now with an eye ahead—on a *matched* Jackson testing set.

*TRADE MARK REG.

BUY WAR BONDS AND STAMPS TODAY

JACKSON

Fine Electrical Testing Instruments

JACKSON ELECTRICAL INSTRUMENT COMPANY, DAYTON, OHIO

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mutual interests and tre
ances being pooled.

Eight directors have
pointed, two from each o
sponsoring groups: R
division, National Electr
tributors Association, A
of Electronic Parts and
ment Manufacturers, a
Managers Club—Eastern

Officers of the new
include: H. W. Clough,
Co., president; Charles
Aerovox Corp., vice-pres
Poncher, Newark El
treasurer; and J. J. Kah
Transformer, secretary.
for the appointment
manager on a full-time
the expectation that a
might materialize by Oc

X-Ray Standard

FOR INDUSTRIAL use of x-r
safety code has been complet
War Committee of ASA (A
Standards Association). I
pected that the code will
basis for a peacetime
which will likewise be de
the job of protecting in
users of x-ray against tissu
age. Previous standards,
larly those applicable to the
field, have been published
National Bureau of Standa
creasing use of x-ray equip
the one- and two-million volt
fications indicates the need f
tection beyond that require
medical practice.

West-Coast Relay

APPLICATIONS have been filed b
ternational Business Mac
Corp. for FCC permission to
terminal stations in Los An
and San Francisco as part o
experimental radio-relay netwo

According to information
leased by GE, suppliers of the g
the relay towers are to be trian
lar in cross-section and about
ft high. A covered platform 35
wide at the top will be reach
by spiral staircase. On each
there will be six antennas, three
reception and three for transm
sion to provide three channels
each direction.

Located within sight of eac
other, the towers will be spaced 5

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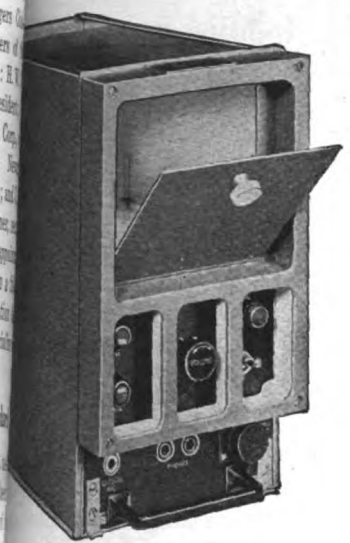
VERT WAR AMPLIFIERS TO CIVILIAN USEFULNESS AND

MAKE A PROFIT



Material

605-D AUDIO AMPLIFIER

ations: Two stage cascade amplifier. Chassis -off cover of 18 gauge steel. Cadmium plated. finish olive drab baked enamel. Dimensions: igh, 6⅝" wide, 12½" deep. Total weight 23½ ss at front to a spares compartment, 5" x 6¼" uitable for locating vibrator or small transmitter.

mpedance: At 400 cycles, 200 ohms; at 1000 00 ohms.

Impedance: Two secondary windings on out- nsformer with one high for minimum 3,500 ohm th wired-in "T" pad attenuator, (control on front) low for 8 ohm load (no control).

Power: At 350 volts plate; nominal 4 watts, um 5 watts.

Requirements for Maximum Output: minus

mpliment: Two type RCA 1619.

Requirements: Low voltage, 12V or 24V DC. oltage, up to 350 volts. Filament and bias con- nominally 2 amps. Plate and screen drain at is 75 to 80 milliamperes.

d for attachment of a No. DM-34-D 12 volt or a 0 24 volt dynamotor which may be available nother source. An 18 contact male receptacle at r connection to dynamotor.

Panels: One filament OFF and ON switch; One e control; One indicator lamp; One fuse; One r single button carbon microphone; and one 4 connector for magnetic microphone; two jacks for mpedance head phones. (Current for carbon micro- is provided as integral part of the amplifier cir- A second 30 contact male receptacle is mounted r of cabinet for connection to external microphones er units when used as an inter-com. system.

sted microphones to use: WEJ 201 carbon or 02 magnetic. Headphones, any good make, 1000 mpedance and up.

parts and wiring readily accessible for alterations ther use and space for addition of one or two tubes required.

The large volume of released electronic equipment no longer needed by our armed forces is a challenge to the inventive genius of the electronic industry. Help to prevent waste. Apply your skill and ingenuity to the problem of converting some of this war equipment to meet civilian needs.

Consider the possibilities of this inter-comm amplifier. It was built to lead a rugged life in U.S. Armored Division Tanks. Easily converted for announcing use in motor buses, police or fire department vehicles; yacht, motor boat or fishermen's loud-hailers. It has space in the spares compartment for a micro-wave transmitter. Or perhaps you have a better idea.

Available in large quantities. New — packed in original cartons. Immediate delivery. Send for a sample. Look it over and experiment with it. Price $10.00, f. o. b. San Francisco. Make checks or money orders payable to Remler Company Ltd.

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Announcing & Communication Equipment

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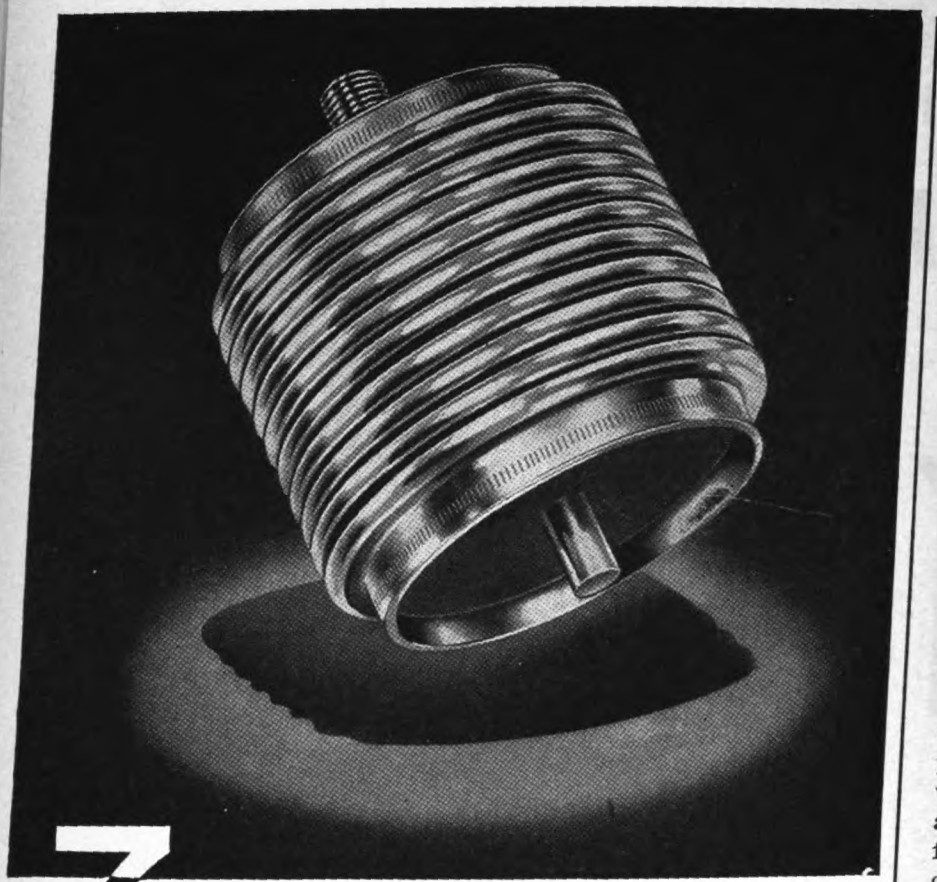

7 Facts You Should Know About C.M.H. *Stainless Steel* Bellows

IF you plan to use bellows for vacuum equipment, instruments, rotating shaft seals, or for other similar purposes in the electronic field, here are some essential features of C. M. H. Stainless Steel BELLOWS:

1. *Corrosion resistant qualities of stainless steel* enable wider application of C.M.H. BELLOWS.
2. *High and low temperatures* do not affect the operating efficiency.
3. *Multiple ply construction* gives even greater strength factors when needed.
4. *Ferrous fittings,* attached by Circular Seam Welding, assure permanent, leak-proof joints.
5. *Uni-metal assemblies* avoid the costly troubles encountered where bi-metal types are used.
6. *Long lengths are standard production* permitting economical use of C.M.H. Stainless Steel BELLOWS for many unusual types of applications.
7. *Better delivery schedules* are possible because C.M.H. BELLOWS are standard production products.

For complete information about C.M.H. Stainless Steel BELLOWS and about the many types of Flexible Metal Hose in the complete C.M.H. line, write us today.

Ask for Chicago Metal Hose Form SSB2 on which to submit your bellows requirements. It will save you time—assure more accurate transmittal of essential data.

Flexible Metal Hose for Every Industrial Use

ARMY E NAVY

CMH

CHICAGO METAL HOSE CORPORATION

MAYWOOD, ILLINOIS

Plants: Maywood and Elgin, Ill.

to 60 miles apart whe
tops are available, but i
try the distance will b
about 30 miles. The
handle two two-way te
grams, four full-fidelity
nels for f-m broadc
radiophoto or facsimi
and 120 business-machi

Industry Prediction

MAKING A STUDY among
vidual manufacturers an
associations with more
members, the Marketing
of CED (Committee fo
Development) concludes
ican manufacturers plan
41.6 percent more good
than they did in 1939. A
price level, the totals ar
000,000 against $80,518,0

Electrical machinery,
fication including dura
products in the electronic
was valued at $1,727,400,0
and is estimated at $2,6
for 1947, or an increase o
cent.

NAB Engineering

AMONG A NUMBER of new
tees appointed by NAB
Association of Broadcaste
engineering executive c
consisting of G. Porter
WCBM, Baltimore, Md.
man); J. B. Fuqua, WG
gusta, Ga.; O. B. Hanso
New York, N. Y.; Karl B. E
WGR, Buffalo, N. Y.; and
B. Lodge, CBS, New York,

Insulator Standards

REVISED TESTS are included i
rent revision of the ASA (An
Standards Association) stand
insulators for supporting ele
conductors. The new sta
C29.1-1944, is a revision of
Insulator Tests standard No.
March 1930, also listed as
C29a-1930. The work include
type, suspension, switch and
guy, spool, wire holder, bus
and tube insulators.

Test data cover 60-cycle we
dry flashover, puncture, co
high-frequency flashover, low
quency withstand voltage, im
withstand voltage, impluse f
over voltage, and radio-influ

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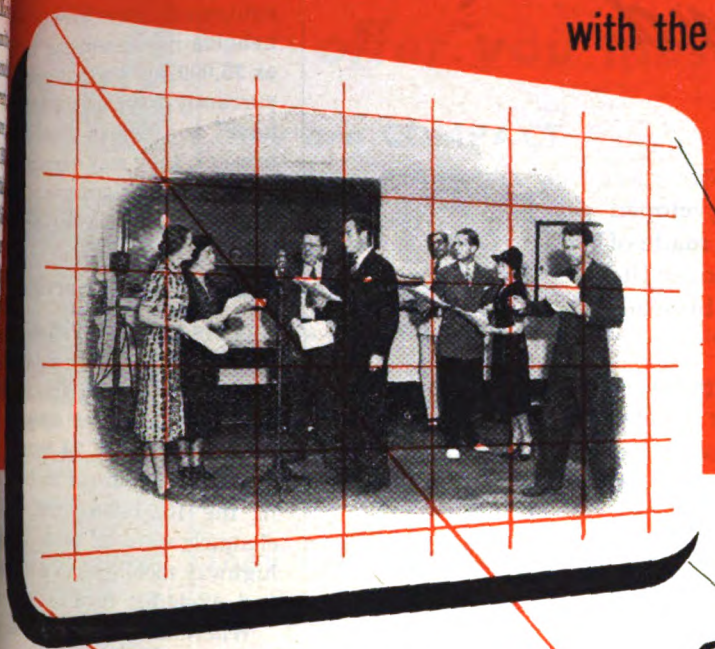
U.H.F. and other measurements, easily, quickly—at your fingertips

★ 25 Millivolts AC Full Scale
★ 700 Megacycles Frequency Range
★ 7 Micro-Microfarads Input Capacity

with the new Reiner Model 451
Vacuum Tube Voltmeter
and Model 101
Amplifier



RANGES:

A. C. VOLTS: 0 — .025 — .1 — .25 (with amplifier) — 2.5 — 10 — 25 — 100 — 250 — 1000

D. C. VOLTS: 0 — 2.5 — 10 — 25 — 100 — 250 — 1000

D. C. CURRENT: 0 — 2.5 — 10 — 25 — 100 — 250 — 1000 Ma.

OHMS: 1 ohm to 1000 megohms

A. C. FREQUENCY RANGE: 10-5000 cps; (with amplifier) — 50 cps. to 700 megacycles

ACCURACY: 2% on full scale — D. C. volt, ohm and current; 2%, 50 cps to 50 megacycles, A. C. volt; 5% accuracy entire A. C. frequency range

OTHER FEATURES Wide Frequency Range • High Input Impedance • One Linear Scale for all Voltage and Current Scales • Wide Voltage Range • Single Zero Adjust for all A. C. and D. C. ranges • Voltage Regulated Supply — Stable Operation • Accuracy 2% of full scale values • Large Overvoltage Capacity • Compartment for Accessories prevents losing or mislaying them; • Many other time-saving, convenience features

MODEL 451, complete with Amplifier Model 101 weighs 20 lbs.; Size: 10¾" x 9" x 8".

For more information on this and other Reiner equipment such as square wave generators, oscilloscopes and signal generators, write Reiner Electronics Co., Inc., 152 W. 25th St., New York 1, N. Y.

Reiner
ELECTRONICS

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HOW CHACE BIMETALS HELPED

Builders of Appliances and Controls

More than twenty years ago Chace developed and introduced thermostatic bimetals made of nickel-chrome steels, which had a longer life at high temperatures than earlier type bimetals made of other alloys.

As a result, the manufacturer of temperature responsive devices was enabled to get a more lasting actuating element and, in consequence, to produce a dependable and more enduring appliance or control. Chace Thermostatic Bimetal thus became "the heart" of many leading temperature indicating and controlling devices whose sales volume steadily increased.

Developed in years of peace, Chace bimetals became vitally important in war, as did the knowledge of our engineering and fabricating divisions, in the application of bimetal to many precision controls.

This knowledge—now fortified by additional hard-won experience—will again be freely offered to manufacturers wishing to refine present designs or to bring out new developments.

W. M. CHACE CO.

Manufacturers of

Thermostatic Bimetals and Special Alloys

1630 BEARD AVE • DETROIT 9, MICH.

CHACE BIMETALS

are made in 35 Specific Types

one of which should precisely fit your needs

SOLD IN SHEETS, STRIPS and FORMS

voltage tests. Data covers ... factors such as mechanical ... trical strengths, thermal ... teristics, and dimensions.

American Standards Ass... is located at 70 East 45th S... York 17, N. Y.

Surplus Equipment

SPB (SURPLUS PROPERTY ... estimates that there will ev... be thrown on the market ... equipment and components t... about $3,000,000,000. Some ... equipment may have a so... nebulus merchandising futu... as $5,000,000 worth of specia... currently surplus. Althou... have no civilian possibili... present, they may very well ... ful to amateur operators wh... are once again on the air.

Mobile Radio Service

GRANTS ARE BEING offered b... for experimentation in two ... of mobile service for which ... quencies have been designate... these two classes, 24 channels ... allocated for urban mobile s... in the 152-162-mc region a... channels were set aside for ge... highway mobile service in the ... and 42-44-mc regions.

Where the facilities are to be ... to obtain factual data relati... needs and requirements of the ... posed service and to collect infor... tion which might be useful in ...

This scroll of greeting being held by Professor Robert Chambers, president of the Union of American Biological Sciences; Dr. Harlow Shapley, director of the Harvard College Observatory, and Professor Harold C. Urey, Columbia University, was presented to the Academy of Sciences of the U. S. S. R. during that organization's 220th anniversary ceremonies in Moscow during June. It was prepared under the auspices of the Independent Citizens Committee of the Arts, Sciences, and Professions

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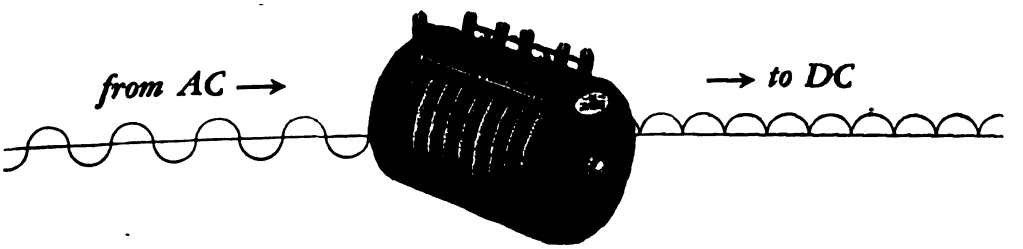

B-L METALLIC ELECTRICAL RECTIFIERS (SELENIUM COPPER SULPHIDE)

offer you these advantages:

They are COMPACT

For a given power output the space required by metallic rectifiers is very small.

They are SILENT

B-L Rectifiers are silent in operation and have no moving parts.

They are DEPENDABLE

Dependability is assured by their simple and rugged construction, in which no glass bulbs, filaments, or other fragile parts are employed.

They are TROUBLE-FREE

Regular maintenance and attention are unnecessary.

They are RUGGED

B-L Rectifiers are rugged and will withstand heavy overloads for short periods of time.

They are ADAPTABLE

B-L Rectifiers are adaptable for power outputs from Milliwatts to Kilowatts.

Many rectifier applications, heretofore considered impractical, have been devised by B-L Engineers. It is more than likely that they can be of assistance in solving your problems of converting AC current to DC . . . Write for Copper-Sulphide Bulletin R38-A — or for Selenium Bulletin R41-A.

THE BENWOOD-LINZE COMPANY
1815 Locust Street . . . . . St. Louis 3, Mo.
Long Distance Telephone CEntral 7830

SALES OFFICES:
420 Lexington Ave. — New York 17, N. Y. — MUrray Hill 5-5875
20 N. Wacker Drive — Chicago 6, Illinois — CEntral 2370

Designers and Manufacturers of Selenium and Copper Sulphide Rectifiers, Battery Chargers, and DC Power Supplies for practically every requirement.

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NOW... get an Instrument Rectifier and a Balanced Resistance network in one convenient plug assembly

it's

Balac

by **Conant**

The lid's off! Now, Conant can give you this new development that meets the demands for applications that involve the balanced bridge principle in AC operation.

A striking example of Balac's many uses is the conversion of standard Wheatstone bridge instruments to AC. AC accuracy and performance become equal to DC operation on the same instrument. Null indication is never affected by temperature, frequency, wave form or line voltage changes.

No priorities necessary—no waiting. Write today for Bulletin R41-A. Balac, by Conant.

Instrument Rectifiers

CONANT ELECTRICAL LABORATORIES

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20 Vesey St., New York 7, New York — 2017 Grand Ave., Kansas City 8, Mo. — 1524 Ivy St., Denver, Colo.
600 S. Michigan Ave., Chicago 5, Ill. — 378 Boulevard N. E., Atlanta, Ga. — Export Div., 89 Broad St., N. Y. 4, N. Y.
1215 Harmon Pl., Minneapolis 3, Minn. — 4018 Greer Ave., St. Louis, Mo. — 50 Yarmouth Rd., Toronto, Canada

ciding the eventual n
ation, a limited numb
izations will be per
ever, the Commission
any assurance that
will be authorized to
tions in the new serv
finally established.

Experimental autho
already been introduc
eral mobile radio serv
western Bell Teleph
Louis, Mo. and Yello
panies of Cleveland, O
ington, D. C. Other
are on file from Bell
panies, Highway R
western Bell Telepho
theon Mfg. Co., Air As
Pacific Freight Lin
Auto Rental Co., Ben
Corp., Tanner Motor
and Federal Telephone
Co.

Theater Loudspeak

UNDER THE SPONSORS
Academy of Motion P
and Sciences a series
being conducted to prov
suring the efficiency of t
speaker systems.

Because previous po
cations have been base
fier characteristics alo
been impossible to speci
acoustical power in a th
torium.

Such standards will b

During the nazi occupation of
patriots of the underground b
operated this tiny clandestine
to pick up *verboten* newscasts.
selenium rectifier in place of
tomary electron type, the circ
energized from a bicycle genera
formed with components "libera
the Philips Radio Works dur
raids—the only time nazi guard
was relaxed sufficiently to ma
feasible

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more efficient ... in miniature

ACTUAL SIZE

The early camera addict had to be both patient and rugged. He carried a bulky camera in one yellow stained hand and a case containing his plates, tripod and cloth in the other. He would laboriously "set up," struggle with focusing and try to keep subjects still for long time exposures. Compare the size of his equipment, his efforts and the results he obtained with those of the user of the modern camera.

Yet the pocket camera of today is no better example of greater efficiency in miniature than is the modern Electronic Tube. In most high frequency circuits TUNG-SOL miniatures function far better than the larger conventional tubes. Because of shorter elements they are more rigid and their lesser mass makes them less prone to distortion as the result of vibration.

TUNG-SOL's principal interest in the Electronic industry is to produce tubes that make radio sets and other Electronic Equipment more effective and efficient. Their engineers are at your service to help plan circuits and select tubes. Consultation, of course, is confidential.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors

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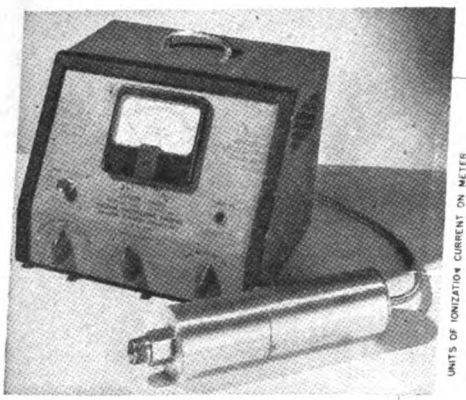
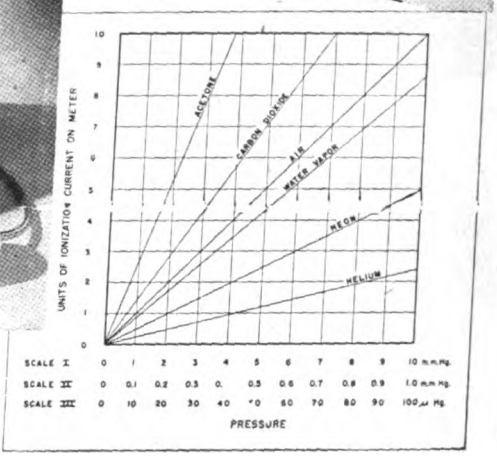
In Vacuum Gauges . . . its the new

Alphatron

No. 3 in series on new developments in the field of High Vacuum





Alphatron Gauge Type 510
Preliminary Calibration Scale

1 micron to 10 millimeters . A single gauge giving continuous linear indication of pressure in three ranges: 1–100 microns; 1–1000 microns and 1–10 millimeters.

instantaneous response . . The Alphatron utilizes the ionization effect of alpha particles. This new principle enables instantaneous response to pressure change and thus avoids lag in readings.

undamaged by atmospheric pressure . . . . . The flow of alpha particles is produced from a sealed radium source. There is no filament to burn out, and the gauge is unaffected by exposure to atmospheric pressure.

simple calibration for different gases . . . . . The graph above shows that the Alphatron has linear reactions to pressure throughout its entire range. Calibrated for dry air the standard Alphatron may be used directly for other gases by means of calibration factors. Excellent for use with systems containing water vapor and for leak detecting.

specifications . . . . . Control box: size 12⅝" x 9¼" x 9⅜", weight 20 lbs., finish grey and black crackle with red trim; gauge (including first stage amplifier); size, 12" x 3" O. D., weight 5 lbs., finish natural; cables: 10 feet special 10 conductor; power 110 volts, 60 cycle, A. C., 1 ampere; calibration as shipped: dry air; shipping weight; approximately 27 lbs.

Vacuum ENGINEERING DIVISION
NATIONAL RESEARCH CORPORATION
BOSTON 13, MASSACHUSETTS, U.S.A.
High Vacuum for Industry

For full particulars send for bulletin G-3.

342

the light of higher efficie loudspeakers which rece dicate are becoming avail it is anticipated that high cies in acoustical levels quired for proper dramat tation of forthcoming wherein improvements in noise ratio, an extensio quency range, and more effects of sound are expe

The Research Council Sound Standardization C under whose sponsorship have been conducted, h mended that theaters u proved loudspeakers to better overall sound result as a way to reduce electric Test equipment for these is installed in the Fox We Academy Theatre, Inglewo where the committee hol ings.

Instrument Society Off

PRO-TEM OFFICERS have beer by The Instrument Soci America as follows: pr A. F. Sperry, Chicago; vic dent, Carl Kayan, profes mechanical engineering, C University, New York, N treasurer, Charles E. Fry, burgh; and secretary, Richar bach, Pittsburgh.

In addition to these elect dividuals, chairman and com members have been establish the following committees: stitution, exhibit, finance, me ship, nominating, program, lications, and publicity.

Radar Shown by Radiation Laboratory

A DEMONSTRATION of microw radar equipment which it had veloped during the past four y was made by the Radiation Lab tories at Massachusetts Instit of Technology late in August members of the technical press.

Occasion for the demonstrat was the conclusion of hostilit and recognition of the virtual co pletion of the developmental wo of the Laboratory. A few remai ing projects are expected to be co pleted by the end of 1945. Th staff of 3800 has for the most pa already returned to the college universities, or industrial concern

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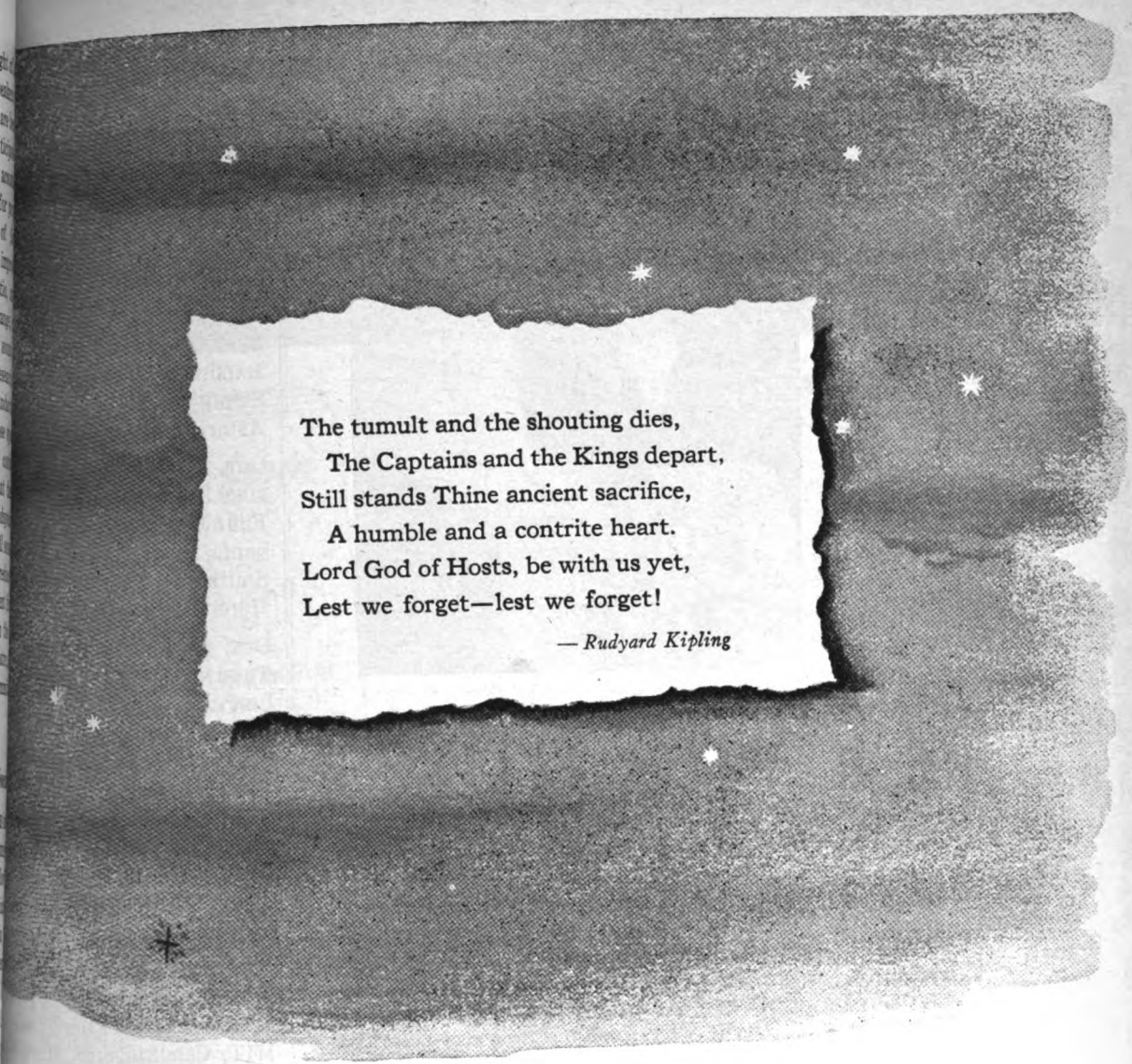

To Our Customers and Friends—

You and we have worked together through four of the world's most tragic years. Our common interest in a common cause has strengthened old business friendships and has made many new ones. For this we are grateful.

This experience of mutual respect and confidence is *one* result of the war that will be carried over to the problems of peace. It is the very stuff that will assure profitable business at home and better relations with our neighbors abroad.

We of the Biddle Company fortunately have no factory problem of reconversion. For the most part, we make the same testing instruments for industry at peace as were required for war. And as more of our products become available for industrial and rehabilitation purposes, we will continue to serve you—in good faith always—and to the best of our ability.

JAMES G. BIDDLE CO.
1211-13 Arch Street, Philadelphia 7, Pa.

"MEGGER" INSULATION TESTERS, GROUND TESTERS AND OHMMETERS • "FRAHM" FREQUENCY METERS AND TACHOMETERS • "JAGABI" RHEOSTATS • INDICATING HAND TACHOMETERS • SCIENTIFIC APPARATUS

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Give Solder STAYING Power

Photo Courtesy of Stanley Tools

USE KESTER FLUXES for Permanence!

➔ Don't risk service difficulties, mechanical failures, with solder flux that won't hold tight! Chemically correct flux—and different fluxes for different types of operations—are imperative for permanent soldering. That's why Kester fluxes are scientifically compounded to form tight, clean solder-bonds resistant to shock, vibration, bending, contraction and expansion. They insure the lasting quality of your product!

➔ For over 45 years Kester Fluxes have been tried, tested and proved dependable. There is a wide range of Kester flux formulas to fit every possible solder operation.

➔ Consult Kester engineers for practical, experienced help in solving any solder problem you may have. They'll gladly suggest the right flux to protect your product—and at no obligation.

BUY VICTORY BONDS

KESTER SOLDER COMPANY

4204 WRIGHTWOOD AVENUE, CHICAGO 39, ILL.
Eastern Plant: Newark, N. J., Canadian Plant: Brantford, Ont.

KESTER Solder Fluxes

STANDARD FOR INDUSTRY

from which they had
cruited. A small staff
prepare material for t
tion of about 30 volume
cal information on micr
niques and electronic de
produced at the Labora

MEETINGS TO C

SEPT. 27-28; SOUTHWARK
BALDWIN LOCOMOTIVE
Strain Gage Conference,
Astoria Hotel, New York,

OCT. 15-17; SOCIETY OF M
TURE ENGINEERS, 58th Sem
Fall Conference; Hotel
vania, New York, N. Y
Smith Jr., Executive
Hotel Pennsylvania.

OCT. 16-18; CARNEGIE INS
TECHNOLOGY AND INSTRU
CIETY OF AMERICA, Educati
ference on Instrumentati
burgh, Pa.; committee c
Dr. B. R. Teare Jr., head
ment of Electrical Eng
Carnegie Institute of Te
Pittsburgh 13, Pa. Invitati
plication only.

OCT. 18-20; OPTICAL SOC
AMERICA, Thirtieth Annu
ing, Hotel Pennsylvania, N
N. Y.; Arthur C. Hardy, se
MIT, Cambridge 39, Mass.

OCT. 19; INSTITUTE OF RAD
NEERS, Cedar Rapids Sectio
phase Broadcasting, by Pau
WHO, and Dehydration by
Frequency, by M. R. Himn
tratherm Co.; Younkers Te
Des Moines, Iowa; J. A. Gre
retary Collins Radio Co., 855
N. E., Cedar Rapids, Iowa.

NOV. 27; INSTITUTE OF RAD
GINEERS, Cedar Rapids Secti
cillators, by Professor W. I
sell, Iowa State College; J. A.
secretary, Collins Radio Co
35 St., N. E., Cedar Rapids, I

JAN. 23-26; INSTITUTE OF RAD
GINEERS, Winter Technical
ing; Astor Hotel, New York,
E. J. Content, chairman of m
committee, WOR, 1440 Broa
New York 18, N. Y.

WASHINGTON NEWS

SURPLUS ELECTRONIC EQUIPM
Electronic equipment and comm
cation gear constitutes the fo
largest class of military su

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- PRECISION WIRE WOUND RESISTORS
- WHEATSTONE BRIDGES
- RADIO & ELECTRONIC TEST EQUIPMENT
- RADAR ASSEMBLIES

A Message from R. S. BRUNEAU

Dear Friends:

An introduction to Eastern Electronics at this time is in order.

"Eastern" is an expansion and growth from the Radio Installation Co. which many will recall I started in 1924 in Boston, Mass. We have grown rapidly during the last few years and are busily engaged on war contracts producing many items for the electronics program.

My associates here include Manfred Johnson, well known for his research and design of meters and recording instruments; and Dave Chapman, well recognized for his work in ultra high frequency Radio and Radar. You real old-timers should recall Bob Ringer formerly a partner in the Hixon Electric Co., Boston.

Our engineering and technical staff is well manned. You can be assured our products will meet the most rigid specifications, both for quality and performance.

Sincerely,

Roland S Bruneau

KORECT-OHM RESISTORS

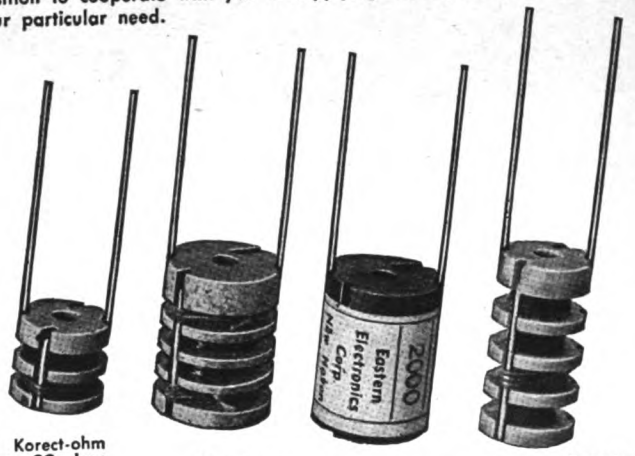
General Specifications

To insure stability Korect-ohm resistors are aged and treated to relieve strains due to winding before the final adjustment is made.

Final resistance adjustment to an accuracy of better than .1%.

TEMPERATURE COEFFICIENT. Resistors are wound with selected alloy wire having a resistance change vs. temperature of less than .08% between —55°C and +55°C. For applications where space is a factor, resistors are wound with an alloy wire having a resistivity of 650 ohms per circular mill ft. the resistance change vs. temperature of this high resistance alloy is .5% ± between —50°C and +50°C.

Many years of experience in the making and applying resistors for precision instruments and electronic equipment places us in a position to cooperate with you in supplying the right resistors for your particular need.



Korect-ohm Type CC low temperature coefficient maximum resistance 250,000 ohms. Type NC maximum resistance 500,000 ohms.

Korect-ohm Type NA maximum resistance 1 million ohms.

Korect-ohm Type CA low temperature coefficient ranges from a few ohms to 500,000 ohms.

Korect-ohm Type CB low temperature coefficient maximum resistance 500,000 ohms. Type NB maximum resistance 1 million ohms.

We will make special resistors to any value and tolerance.

Our regular line of resistors are available for immediate delivery.

Watch our Ads for New Items.

Eastern Electronics Corp.

41 CHESTNUT STREET, NEW HAVEN, CONN.

Boston Sales Office
11 Pemberton Square
Tel. Capitol 2425

Chicago Sales Office
Bauman & Bluzat 2753 West North Ave.
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No. 5 of a Series

MODERN COIL WINDINGS

Partial View of Assembly Department

For many months, COTO-COIL facilities have been employed in producing wartime essentials. Now, as we so long hoped, our entire plant can be devoted to peacetime industry.

Our 28 years of experience are at your service to help you with modern coil design and construction.

COTO-COIL CO., INC.

COIL SPECIALISTS SINCE 1917

65 PAVILION AVE. PROVIDENCE 5, R. I.

capital and producers' for disposition by Re Finance Corp. The two are electron tubes wil inal cost of $15,989,00 ponents and subassembl 304,000.

FCC APPLICATIONS. On 1945, FCC issued a pu outlining the procedure handling standard broa cations under their exis It was announced that period would be provid filing of new applicat manpower and materi reach the situation whe licensing practice is to b lished. This 60-day perio nounced to have comme ning on August 7, 1945. will not be required to they have the necessary on hand. After October 7, consider applications fi viously and also those file the 60-day period. Howeve television applications ca acted upon until regulati been adopted.

WPB CONSOLIDATION. Th and transport bureau of W been abolished and its transferred to the equipm reau, all except the Radio an Division. This organizat longer comes under bureau but is now under the office operations vice-chairman.

FCC ACTS

To permit:	To do this:
WPXLA Denver, Colo.	Operate with changed f 43.5 mc and class changed from tempora experimental high-fre developmental broadcas power.
— — — — Cincinnati, Ohio	Construct new station to WCPO on frequencies o 35,620, 37,020, 39,26 10 w power.
— — — — Gallup, N. M.	Construct new station to op 1230 kc at 250 w, unlimit
— — — — Findlay, Ohio	Construct new relay b station on frequencies of 33,740, 35,820 and 37,1 with 25 w power.
WSSV Petersburg, Va.	Operate newly constructed on 1240 kc, 250 w, unlimite
— — — — Grand Island, Neb.	Construct new station to re KMMJ on 30,820, 3 35,820 and 37,980 kc with power.
WHGB Harrisburg, Pa.	Operate a newly constructe tion on 1400 kc with 250 limited time.

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mous KENYON T-LINE TRANSFORMERS

BORN IN THE EARLY 1930's...

TODAY THE MOST COPIED-OF-ALL TRANSFORMER HOUSINGS

THE MARK OF EXCELLENCE

enyon, take a good deal in our famous **T-LINE ORMERS.** Similar units produced and adver- many of our competi- long ago realized that **NE** Housing was a su- ousing in many respects ating by years the un- pen-type Transformers d by other Transformer cturers.

ditional features of the famous

KENYON T-LINE

are:

- ***Excellent Appearance***
- ***Universal Mountings***

ing centers remain exact because they e-punched all at the same moment in a operation.

- ***A Manufacturer's Dream***

se they provide an excellent electrical mechanical design that can be made ly from plentiful materials.

yon is extremely satisfied with its outstanding engineering developments. The **KENYON T-LINE** case when duced in the early 1930's was years ahead of its time.

Our engineers are indeed proud to be the originators of such a popular design and point to its duplication h pride.

Kenyon engineering intends to maintain its place as a pioneer in the continued development of outstanding ansformer Equipment.

Inquiries invited. Write for our NEW 1945 Illustrated Catalog

KENYON TRANSFORMER CO., Inc. 840 BARRY STREET NEW YORK, U. S. A.

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LET US HELP YOU WITH YOUR CRYSTAL CONTROLLED CIRCUITS

The public may be very happy just to have a new automobile. But they are conditioned to expect the postwar domestic radio to be different — with the precision and quiet of Crystal Controlled circuits.

Through the war we have learned a lot about the use of Control Crystals, and this knowledge is at the disposal of manufacturers of radio, fm and other electronic devices.

And when you know what crystals you need, our quantity-production methods are ready to supply you with crystals to your exact specifications, on time, clean, and at a price that will be within your production budget.

ARMY E NAVY

PAN-ELectronics LABoratories, Inc.

500 Spring St., N. W. Atlanta, Georgia

Pan-El QUANTITY PRODUCERS OF STANDARD AND SPECIAL Control Crystals

To permit:	To do this:
KRMD Shreveport, La.	Change automatic t trol equipment.
KXOA Sacramento, Calif.	Operate a newly c tion on 1490 kc, 2
WKAO San Juan, Puerto Rico	Operate moved tra and auxiliary transm
WHTB Talladega, Ala.	Change antenna st structed station.
Philco Radio & Television Corp. Wyndmoor, Pa.	Construct experimen broadcast station to vision system operat to 920 mc region w to be assigned a Special, and Specia f-m, power 1 kw (pe aural. Also constr perimental televisio on frequencies to be A1, A3, A5, Specia for f-m emissions.
W2XRA New York, N. Y.	Operate a newly developmental broad
Allen B. DuMont Labs., Inc. New York, N. Y.	Construct portable-m mental television re the 480 to 920 mc frequencies to be as Special, and Speci emissions, 1 kw (peak aural power.
Emerson Radio & Phonograph Corp. New York, N. Y.	Construct new de broadcast station on fr be assigned. A0, A3, emission for f-m.
J. F. Novy Riverside, Ill.	Construct new de broadcast station on fr be assigned. A0, A emission for f-m.
General Railway Signal Co.	Construct and operate experimental Class 2 and portable-mobile tions in yard and termin along the roads of pri roads. Frequencies a assigned. Power is 60 w A1, A2, A3, and Speci and hours of operation
KUSC Los Angeles, Calif.	Extend completion dat non-commercial educatio cast station to Dec. 21, 1
W3XO Washington, D. C.	Operate at new site and of station changed from t class 2 experimental frequency broadcast to mental broadcast.
KIT Yakima, Wash.	Operate with change in tra equipment.
— — — — State College, Pa.	Construct new station to op 1450 kc, 250 w, unlimited
KLS Oakland, Calif.	Change calls letters to KW
Bendix Aviation Corp.	Construct three identical mental Class 2 portable a table-mobile stations and ate for experiment in con with the development and of railroad radio communi systems. Composite tran will operate at 10 w, with A A3, and Special emissions f (telephony) on frequencies assigned.
Halstead Traffic Communications Corp., Weehawken, N. J.	Construct and operate two ne perimental Class 2 radio stati use to determine relative me f-m and a-m for communi between a central office and ing trains or switch engines. quencies will be assigned.
Raytheon Mfg. Co.	Construct five experimental relay stations to be installed tween Boston and New York Intermediate locations will

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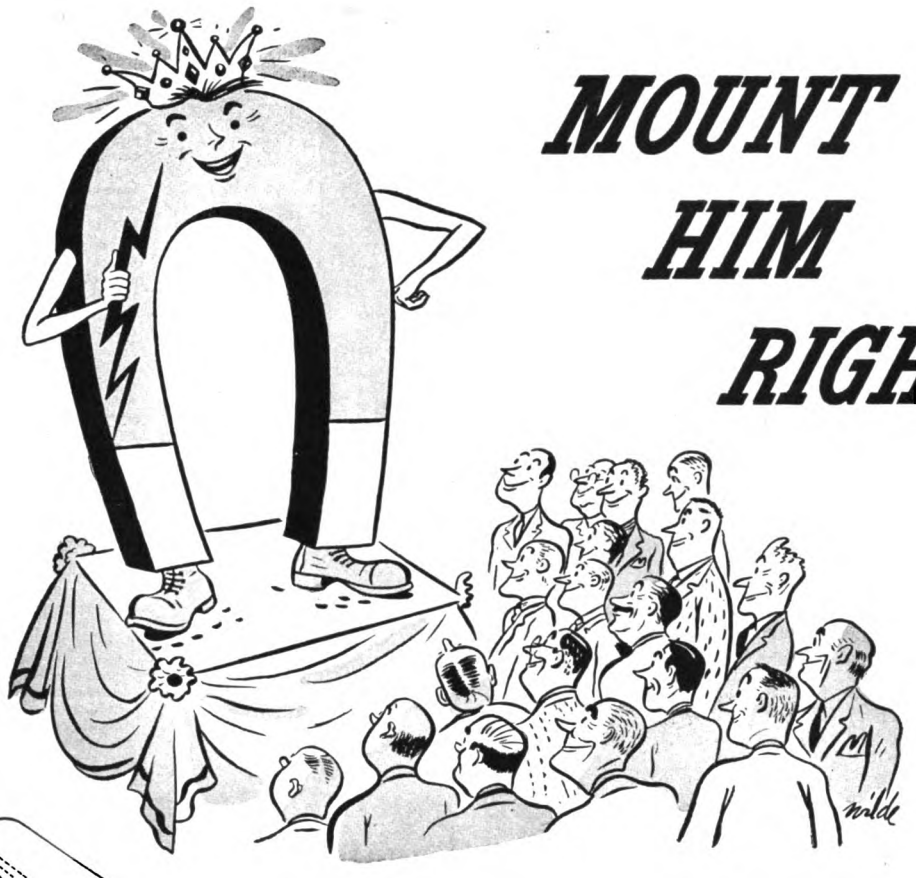
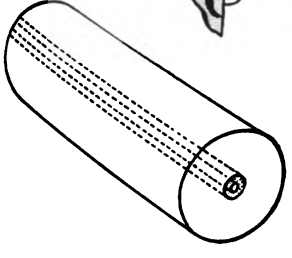
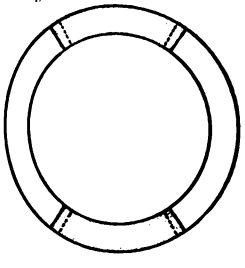
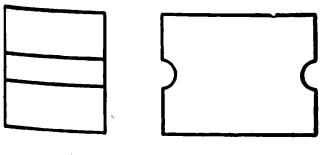
MOUNT HIM RIGHT!









Much as he would like to be, he's no hero, this permanent magnet. However, he should be well mounted. He doesn't need a pedestal so that all the world can admire him, but he does need to be so designed that he can be mounted properly in the instrument or machine he is to serve. Otherwise he may sulk and loaf on the job.

Most permanent magnets are prepared for mounting in one of three ways:

1. By casting small holes or slots or shaft holes into the magnets
2. By casting soft iron inserts into the magnet
3. By casting the magnet into a housing wall

But which method to choose . . . that's the problem!

The selection of the proper mounting for a magnet need not be too troublesome once the advantages and disadvantages of all methods are understood. Our engineers will be glad to advise on this point at any time but perhaps a reading of our pamphlet PERMANENT MAGNET DESIGN will be helpful to those designing their own magnets. Shall we send *you* a copy?

10-CC-1

CINAUDAGRAPH CORPORATION

ARMY (E) NAVY

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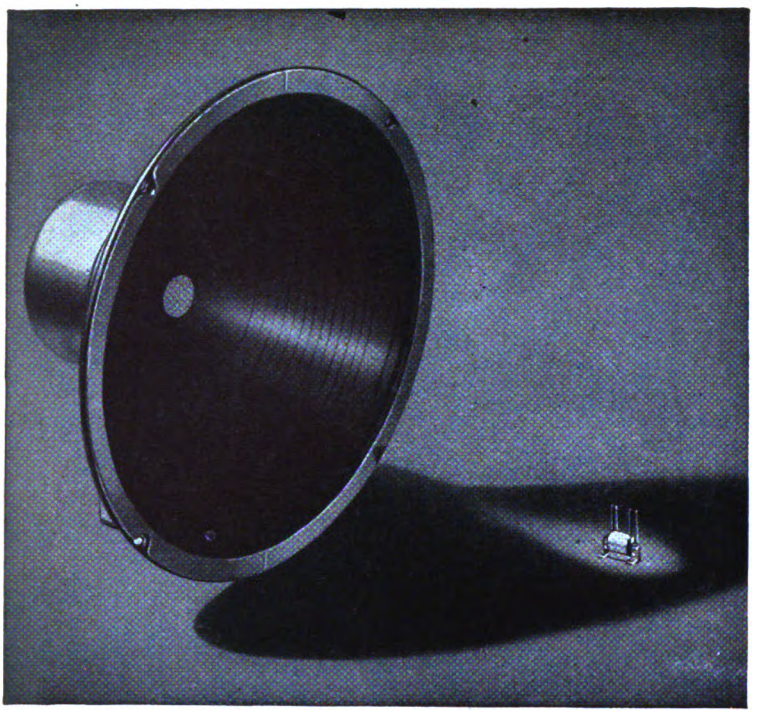

Permoflux Speakers and Transformers Set New Standards of Comparison!

New Permoflux speakers in a complete range of true-dimensioned sizes from 2" to 15", with power handling capacities from 1 to 20 watts, provide the finest sound reproduction for every application.

Permoflux midget transformers, with their many practical circuit applications, have literally revolutionized efficiency concepts where size and weight are determining factors.

Advanced engineering designs, improved manufacturing methods and new materials have all contributed their share in the development of Permoflux speakers, transformers, microphones and headphones. You can count on Permoflux to provide an acoustical unit to suit your exacting requirements.

BUY WAR BONDS FOR VICTORY!

TRADE MARK

PERM-O-FLUX

PERMOFLUX CORPORATION

4900 WEST GRAND AVE., CHICAGO 39, ILL.

PIONEER MANUFACTURERS OF PERMANENT MAGNET DYNAMIC TRANSDUCERS

To permit:	To do this:
	Lexington, Mass., Bristol and Tolland, Conn., and Webster, Mass. Experimentation will involve Class 2 point-to-point radio stations to develop new techniques for the transmission and relaying of high definition and color television programs, high-fidelity f-m and telephone, telegraph and facsimile. Power of 100 w will be used on frequency bands to be assigned.
WLBZ Bangor, Maine	Change from directional antenna day and night to directional antenna night only.
WMAZ Macon, Ga.	Operate with nighttime directional antenna pattern from 15 min before local sunset to 15 min after local sunrise during those months in which the average hour of local sunset and/or local sunrise occurs on the quarter-hour or three-quarter hour.
Seaboard Air Line Railway Co.	Construct four experimental Class 2 portable and portable-mobile stations to investigate possible improvements in public transportation. Frequencies are to be assigned, power is 25 w with Special emission for f-m (telephony).
Raytheon Mfg. Co.	Construct experimental Class 1 portable radio station for conduct of field strength measurements and determination of propagation characteristics from a series of Western mountain peaks. Frequencies will be assigned, power 250 w with Special emission for f-m.
Southwestern Telephone, Telegraph & Power Co.	Construct one experimental Class 2 radio land station and twelve portable mobile stations to be installed in repair trucks and supervisory cars. Frequencies will be assigned. Power 250 w for the land stations and 15 w for the portable-mobile station with Special emission for f-m.

BUSINESS NEWS

BENDIX AVIATION CORP. anticipates the early installation of radar network systems which will make all-weather flight a reality. Using radar landing techniques, airlines will be able to take off, fly, and land safely under all weather conditions short of a full gale.

OTRONICS COMPANY OF AMERICA, INC. New York, N. Y., is a new company formed to handle a newly developed aid to hearing.

HALSTEAD TRAFFIC COMMUNICATIONS CORP., New York, N. Y., has been acquired by Farnsworth Television and Radio Corp., Fort Wayne, Ind. The Halstead engineering staff as well as the laboratory and manufacturing facilities will be transferred to Fort Wayne.

AUDAR, INC. is the name of a newly formed corporation, an affiliate of John Meck Industries, Inc., Chicago Ill. It will manufacture and sell

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That's how they make ONE type of Fiberglas*-Mica combination

Several processors were quick to realize that mica and Fiberglas each have advantages which, when combined, result in an insulation material with unsurpassed characteristics. That is why the combination of thin glass cloth with mica, for ground insulation, was one of the first applications of Fiberglas in the electrical industry.

Types of Fiberglas-Mica Combinations

Fiberglas-Mica combination insulation is available commercially in thicknesses from .004" to .030". The Fiberglas may be applied to one or both facings of the mica, and the thickness of the Fiberglas used may be varied.

For ease in using the material, where minimum space is a factor, Fiberglas may be applied to one surface of the mica, while "fish paper" is applied to the other. In all cases, the strength of the Fiberglas-Mica combination is in excess of any other type of reinforced mica of the same thickness. This is particularly important in the thinnest mica tapes used for conductor or coil insulation. Four mil thick Fiberglas-Mica Tape is nearly three times as strong as the same thickness of mica tape with silk or paper backing—thus reducing application time.

Typical Applications

Fiberglas-Mica combination materials are used wherever there is a need for maximum reliability under high temperatures, either internal or external; where mechanical service is most severe, where a maximum safety factor is required. Its chief use is as ground or slot insulation in motors and generators, as phase insulation in large a-c apparatus, or as coil insulation between high and low voltage sides of dry-type transformers.

Complete Information

If you do not have complete information about Fiberglas-Mica combinations, write for the new EL 44-7 catalog, today. It also contains data on Fiberglas Tapes, Sleeving, Cord, etc. The name of the Fiberglas Insulation Materials Supplier located nearest to you will be supplied on request.

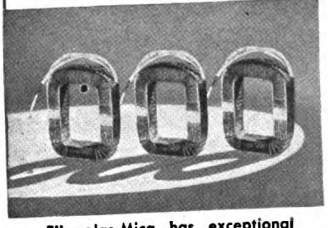
Owens-Corning Fiberglas Corporation, 1860 Nicholas Building, Toledo 1, Ohio.

In Canada, Fiberglas Canada Ltd., Oshawa, Ontario.

There is a **FIBERGLAS** Insulation Material for every need

Fiberglas-Mica Sheets or Tapes are available in thicknesses from .004" to .030"—with Fiberglas facings on one or both sides.

One of the chief uses of Fiberglas-Mica combinations is as ground or slot insulation in motors and generators.



Fiberglas-Mica has exceptional strength, permitting use of thinner tapes for conductor or coil insulation.

Write for catalog EL 44-7, today.

Each distributor of Fiberglas-base Insulation Materials has his own source of supply, since Owens-Corning Fiberglas Corp. does not process these materials.

FIBERGLAS

*T. M. Reg. U. S. Pat. Off.

ELECTRICAL INSULATION MATERIALS

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another Audio Development

Our Variable
SOUND EFFECTS FILTER

One of hundreds of basically different filter types produced by Audio Development, this unit has been designed principally for the use of broadcasting stations and recording studios. The filter consists of a single prototype low pass and a similar high pass filter section, each with eight different cut off frequencies. This permits the selection of a proper cut off frequency for any application.

Attenuation of at least 18 DB per octave is obtained for both high and low pass sections with the insertion loss in the pass band less than 1 DB. Coils are individually shielded to permit normal operating levels between −40 and +14 VU. Standard impedance is 600 ohms. Mounting facilities are provided within the unit for transformers, thereby permitting operation in systems of any impedance.

DO YOU HAVE A FILTER PROBLEM?

ADC

Audio Development Co.
2833 13th Ave. S., Minneapolis, Minn.
"Audio Develops the Finest"

sound systems and audio amplifiers.

SYRACUSE UNIVERSITY, Syracuse, N. Y., plans to install a wired television system for use in the conduct of classroom equipment experiments as well as program instruction. General Electric Co. will be the supplier.

RADIO CORP. OF AMERICA adds to its present list of products a complete line of dry batteries. They will be handled by the tube division in conjunction with RCA tubes and parts.

SYLVANIA ELECTRIC PRODUCTS, INC. is leasing an armory building in Scranton, Pa., to serve as a new tube feeder plant for the Williamsport, Pa. electron tube factory.

GENERAL ELECTRIC CO. has an order from Don Lee Television and Don Lee Bradcasting Systems, Hollywood, Calif., for a 40-kw television transmitter. The plan is to install the gear 5,800 ft. above sea level on Mount Wilson and use the present facilities of Station W6-XAO in Los Angeles as a relay station and studio site.

E. I. DU PONT DE NEMOURS & CO. begins production of luminescent chemicals for cathode ray tubes in its new Towanda, Pa. plant. This facility is in the Patterson Screen Division of the photo products department and involves the latest in equipment and techniques for zinc and cadmium phosphors for specific applications.

VULCANIZED RUBBER COMPANY changes its name to Vulcanized Rubber and Plastics Co. Facilities are located in New York City and Morrisville, Pa.

RADIO CORP. OF AMERICA has received from a B-25 bomber crew a Radiotron carton which bears battle autographs including Salerno, Algiers, Avellino, Corsica, Bizerte, Tunisia, Rome, and Naples. One of the crew members is the son of a worker in the Harrison, N. J. tube plant.

INTERNATIONAL DETROLA CORP. proposes to merge Utah Radio Products Co., Chicago, Ill., and Universal Cooler Corp., Marion, Ohio, into its organization. The group and their subsidiaries own and operate a total of nine manufacturing plants in this country and two in Canada.

F. J. STOKES MACHINE CO., Phil-

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LET'S LOOK UNDER *THEIR* BUSHELS!

Many and valuable—even spectacular—are the wartime achievements of the electronic industry. On land, at sea and in the air, men and fighting equipment have moved into action with amazing synchronization—victories have been won—many lives and days have been saved—through the direction, guidance and safety of electronic creations. The contributions of electronic devices to all-time war production records here at home are equally amazing. In fact, the needs of war have given such immense impetus to the value of electronics in the communications and industrial fields that it has become one of our Nation's great industries whose peacetime future is full of rich promise.

This war-stimulated progress reflects great credit, indeed, on the genius and resourcefulness of the entire electronic industry—and especially on the tube manufacturers of America. For largely because of their pioneering accomplishments in developing and supplying new kinds of tubes for the many new-found war uses, along with improving existing types, has it been possible to put electronics to work in so many places. Making tubes is *not* our business. Yet we at Speer are keenly aware of the almost incredible wartime record achieved by those who do while taking little or no credit for themselves. For their vital—though still largely censored and unheralded role in gaining Victory, it seems uniquely fitting to say "Well done" to all tube manufacturers, many of whom it has been our privilege to serve.

PRODUCERS OF ELECTRONIC TUBES

Amperex Electronic Products
de Forest Laboratories, Lee
Eitel-McCullough, Inc.
Electronic Enterprises, Inc.
Federal Telephone and Radio Corp.
General Electric Co.
General Electronics Company
General Electronic Industries
Heintz & Kaufman, Ltd.
Hytron Corp.
Ken-Rad Tube & Lamp Corp.
Machlett Laboratories
National Union Radio Corp.
North American Philips Co.
Raytheon Mfg. Co.
Radio Corp. of America
Sal-Mar Laboratories
Slater Electric & Mfg. Co., Inc.
Sperry Gyroscope Co., Inc.
Sylvania Electric Products, Inc.
Taylor Tubes, Inc.
Translite, Inc.
Tung-Sol Lamp Works, Inc.
United Electronics Co.
Western Electric Co., Inc.
Westinghouse Lamp Div.,
Westinghouse Electric & Mfg. Co.

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WILEY Books in COMMUNICATIONS-ELECTRONICS

Scientific progress is entering upon a new productive era. Now is the time to step up your knowledge. Be ready for new ideas . . . profitable opportunities. Look over the important titles listed below. Then, make your selection and order from the coupon today.

PRINCIPLES OF RADIO—Fifth Edition

By Keith Henney

1945 534 Pages $3.50

Designed for those with or without technical training in radio who want a working knowledge of the basic principles of radio communications. Starts with the fundamental principles of electricity, and gradually develops the subject of radio practice. Thoroughly revised to include recent developments and future methods.

FIELDS AND WAVES IN MODERN RADIO

By Simon Ramo and John R. Whinnery

1944 503 Pages $5.00

An authoritative coverage of this field, requiring only a basic knowledge of elementary calculus and physics, which gives a rigorous account of the technique of applying field and wave theory to the solution of modern radio problems.

HYPER AND ULTRA-HIGH FREQUENCY ENGINEERING

By Robert I. Sarbacher and William A. Edson

1943 644 Pages $5.50

A practical treatment of an important new branch of communications engineering, requiring no special advanced knowledge. Of value to the beginner, as well as to those having some familiarity with the subject.

FUNDAMENTALS OF ELECTRIC WAVES

By Hugh H. Skilling

1942 186 Pages $2.75

Discusses the principles of wave action as applied to engineering practice, with particular emphasis on the basic ideas of Maxwell's equations and repeated use in simple examples; also on physical concepts and mathematical rigor.

APPLIED ELECTRONICS

By the Electrical Engineering Staff, Massachusetts Institute of Technology

1943 772 Pages $6.50

Provides a thorough understanding of the characteristics, ratings, and applicability of electronic devices. Gives a working knowledge of the physical phenomena involved in electronic conduction, plus its applications common to various branches of engineering.

PRINCIPLES OF ELECTRONICS

By Royce G. Kloeffler

1942 175 Pages $2.50

Tells clearly and simply the story of electron theory and the operation of the electron tube. Beginning with the discovery of the electron and the forces of attraction and repulsion of charged particles, the entire action taking place in electronic devices is carefully explained.

HIGH FREQUENCY THERMIONIC TUBES

By A. F. Harvey

1943 244 Pages $3.00

Gives the details of these important new tubes and describes the experimental work that has been done with them. Presents a thoroughly comprehensive account of the properties of thermionic tubes at very high frequencies and their relation to those of the associated electric circuits.

THE TECHNIQUE OF RADIO DESIGN

By E. E. Zepler

1943 312 Pages $3.50

Thoroughly practical, this treatment of radio design deals with the day-to-day problems of the radio engineer, both in the development and in the testing of radio receiving apparatus of all types.

ELECTRON OPTICS AND THE ELECTRON MISCROSCOPE

By V. K. Zworykin, G. A. Morton, E. G. Ramberg, J. Hillier, and A. W. Vance

1945 Approx. Pages 759 Probably $10.00

A comprehensive coverage of the entire field, presenting a thorough discussion of various types of electron microscopes, and offering a survey of theoretical and practical electron optics.

TIME BASES—(Scanning Generators)

By O. S. Puckle

1943 204 Pages $2.75

Covers the subject from both the design and the development points of view; assembles more time bases circuits than have heretofore been available in one volume.

HOW TO PASS RADIO LICENSE EXAMINATIONS—Second Edition

By Charles E. Drew

1944 320 Pages $3.00

This revised edition of a well-known book offers recent material for amateur radio operators, radiotelephone and telegraph operators, whether in the broadcasting, marine, aeronautical, or any other field of transmission or reception.

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Employed by E-9-45

adelphia, Pa., will manufacture and sell the all-electronic drying system developed by RCA to produce penicillin.

THE ROBINSON-HOUCHIN OPTICAL CO., Columbus, Ohio, has changed the name of its electronic equipment from Radiotone to Rad-O-Recorder.

INDUSTRY INVENTIONS, INC. has been established in Ohio to license the use of electronic vulcanization in the manufacture of rubber and plastic products. Available patents will be those held by B. F. Goodrich Co. and Firestone Tire & Rubber Co.

STROMBERG CARLSON CO., Rochester, N. Y., is building a $300,000 annex with a capacity of 60,000 sq. ft. Space will be used for making cabinets.

MAJESTIC RADIO & TELEVISION CORP. is building a new factory just north of the Elgin, Ill., city limits. The plant, the company's third, will involve about 160,000 sq ft with plans for expansion to 243,000.

VIEWTONE CO., New York, N. Y. has introduced the low-cost table model

television receiver illustrated herewith. It is designed to retail at approximately $100.

MEISSNER MFG. CO., Mt. Carmel, Ill., is purchased for cash by Maguire Industries and merged with the latter concern as an independent division. No changes are planned in policy or operation except that there will be an expansion of sales volume made possible by increased capitalization.

RADEL MFG. CO., Cleveland, Ohio, is a new company founded to manufacture a line of automobile radio antennas as well as radio parts and

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RESISTOR DATA

For the convenience of designers of products requiring resistors, Ward Leonard offers this new Resistor Handbook. It describes in detail the full line of wire-wound resistors giving complete information on mountings, enclosures, terminals and resistance values. Write for your copy today.

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RELAYS • RESISTORS • RHEOSTATS

Electric control (WL) *devices since 1892.*

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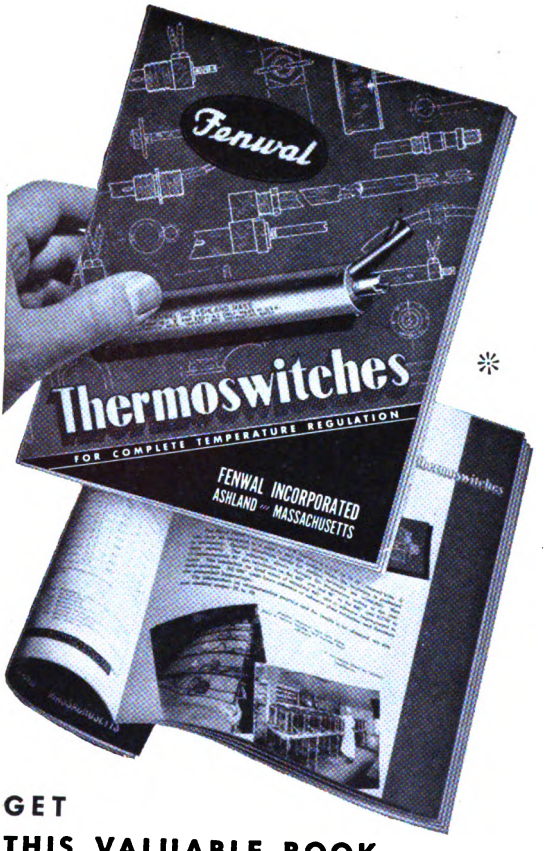

GET
THIS VALUABLE BOOK
On Temperature Control

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TO ELECTRICAL EQUIPMENT MANUFACTURERS

Before deciding on temperature regulating devices for your products, be sure to investigate Fenwal Thermoswitches. They operate on an unusual principle, and offer many advantages not found in other types of switches. The Fenwal Engineering Data Book contains detailed drawings of construction of various models and typical installations.

- Compact construction permits installation in tight places.
- Make and break unaffected by external vibration.
- Readily adjustable for wide range of temperature control.
- Minutely accurate.
- Adaptable for all types of media.
- Inexpensive.

• A 44-page treatise on Thermal Control including installation drawings, photographs, blueprints and descriptive suggestions for future planning with basic principles involved in temperature regulation and control. . . . Just write for your *free* copy on your business letterhead.

"IF IT'S A FENWAL—IT'S THE BEST OF ALL"

THERMOSWITCHES
Fenwal Inc.
FOR COMPLETE TEMPERATURE CONTROL
48 Pleasant Street, Ashland, Massachusetts

equipment. It is headed by Sidney Ludwig, former chief engineer of Ward Products.

HOFFMAN RADIO CORP. has under construction a new plant annex, is at the same time leasing three other buildings, and has purchased a new brick 32,000 sq ft structure adjacent to its present quarters in Los Angeles, Calif.

GENERAL ELECTRIC X-RAY CORP. moves its main office from the plant to the Insurance Exchange Bldg., 175 Jackson Blvd., Chicago. The five-story building thus made available will be used for manufacturing purposes.

FEDERATION OF BROADCASTING ASSOCIATIONS is the name of a newly merged organization including Holland's four leading broadcasting associations which before the war shared two stations at Hilversum.

EMERSON RADIO & PHONOGRAPH CORP. has launched its postwar product and policy campaign by revealing the design of specific models of its projected radio receivers.

FERROCART CORP. OF AMERICA and Micro Products Corp., both located in Hasting-on-Hudson, N. Y., have been acquired by Maguire Industries Inc.

PERSONNEL

ANTHONY LAMBO becomes vice-president and general manager of Mectron Corp., Lawrence, Mass. In this capacity he heads up electronic and mechanical engineering activities in the company.

MELVIN E. KARNS, RCA Victor Division, RCA, Camden, N. J., is designated director of the Radio and Radar Division of WPB. He succeeds Louis J. Chatten. Mr. Chatten becomes vice president and general commercial manager of North American Philips Co., New York, N. Y. John Creutz becomes assistant director for production to replace Mr. Karns.

FRANCIS X. RETTENMEYER is appointed chief components engineer of Federal Telephone and Radio Corp., Newark, N. J. Mr. Retten-

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Don't Let Repairs and Replacements Leave You "Holding the Bag"

Make sure wire meets the "specs" for trouble-free performance in every service condition

You may not be able to anticipate everything that your product will stack up against in service . . . but you should consider all probable trouble factors such as high operating and ambient temperatures, vibration, moisture, fungus, oil, grease, corrosive fumes and fire hazard . . . then wire-plan for dependable performance by selecting wires, cables and cords that meet your requirements and provide *an ample safety margin* as well.

For performance protection that pays off in satisfied customers by practically eliminating wire-failure breakdowns, rewiring, replacements and service calls, specify Rockbestos *permanently insulated* wires, cables and cords. Every one of the 125 different standard constructions, ranging from 1000 volt No. 22 Radio Hookup Wire to 5000 volt Rockbestos A.V.C. Power Cable, was designed to provide a better wire for a severe or unusual application . . . and Rockbestos Research is always willing to work up a special if you need it.

A phone call or letter will bring complete information or engineering assistance in your wire-planning from the nearest district office or:

ROCKBESTOS PRODUCTS CORPORATION
428 Nicoll Street, New Haven 4, Conn.

New York Buffalo Cleveland Chicago Pittsburgh St Louis
Los Angeles San Francisco Seattle Portland, Ore.

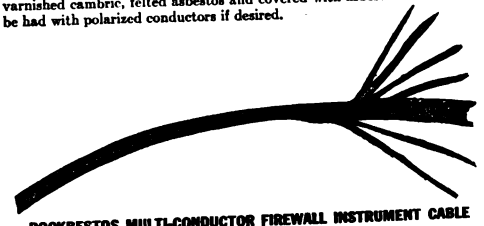
A few of the 125 different wires, cables and cords developed by Rockbestos to meet severe or unusual operating conditions.

ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

The first lightweight, small diameter, flame-resistant hookup wire designed in 1937 and widely used since in airborne and ground communications systems, electronic devices, instruments and apparatus. Operating temperatures range from 125° C. to minus 50° C. Also with tinned copper shielding braid and in twisted pair or tripled construction. Sizes No. 22 to 4 AWG in 1000-volt rating, and No. 12, 14 and 16 AWG in 3000-volt.

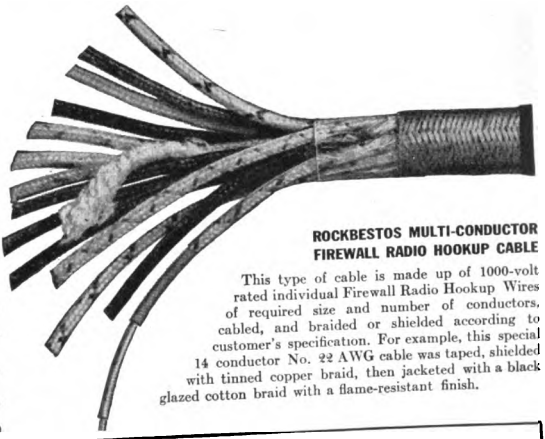
ROCKBESTOS A.V.C. 600 VOLT FLEXIBLE CORD

This heat-resisting flexible cord is ideal for apparatus leads, etc., where a heavy duty high-dielectric, heat and moisture resistant cord is required. Labeled cord with polarized conductors if desired. Sizes No. 10 to 18 AWG with two or three conductors insulated with impregnated felted asbestos, varnished cambric, felted asbestos and covered with asbestos braid. May be had with polarized conductors if desired.



ROCKBESTOS MULTI-CONDUCTOR FIREWALL INSTRUMENT CABLE

This unusually small diameter, light weight, high-dielectric No. 26 AWG three conductor cable was designed for an electronic device in which three No. 22 AWG single conductor aircraft circuit wires previously used proved too bulky. It is made to a nominal diameter of .125" (smaller than a No. 14 AWG single conductor 1000-volt Rockbestos Firewall Radio Hookup Wire). Also made in four, five and six conductor construction, and in No. 24, 22 and 20 AWG.



ROCKBESTOS MULTI-CONDUCTOR FIREWALL RADIO HOOKUP CABLE

This type of cable is made up of 1000-volt rated individual Firewall Radio Hookup Wires of required size and number of conductors, cabled, and braided or shielded according to customer's specification. For example, this special 14 conductor No. 22 AWG cable was taped, shielded with tinned copper braid, then jacketed with a black glazed cotton braid with a flame-resistant finish.

Another New Rockbestos Firewall Construction!

War-developed Rockbestos High-Temperature Wire — *with a maximum operating temperature of 400° F.* — designed for jet propelled plane applications and circuits to hot-wing de-icers, fire detectors and extinguishers, and air conditioning and heating units where baking temperatures destroy ordinary insulation. Under continuous operation at rated temperature it retains its original dielectric strength and inherent resistance to heat and flame, and *progressively improves* in its resistance to moisture and abrasion. It is now available for these and other severe applications. Write for complete information and samples.

ROCKBESTOS RESEARCH
Solves Difficult Wiring Problems
Invest in U. S. Victory Bonds!

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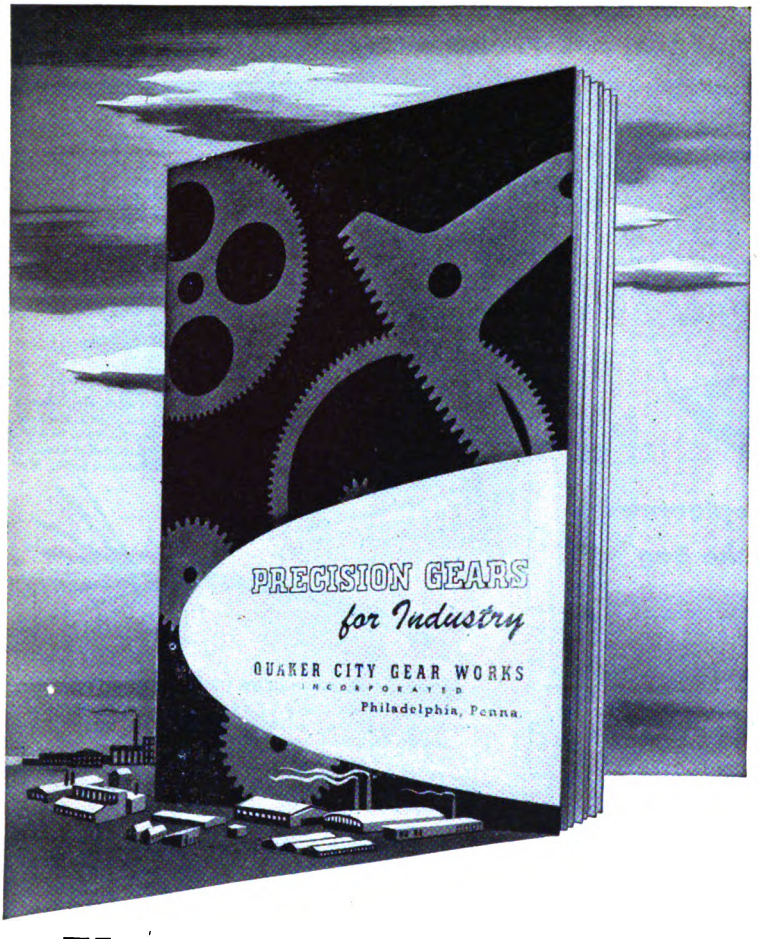
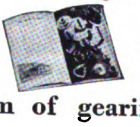


Yours for the asking

A new informative booklet on gears. It has illustrated sections  on practically every known form of gearing, together with many reference tables and formulas. Write for your copy today on your company stationery.

Quaker City Gear Works
INCORPORATED

1910 N. Front Street, Philadelphia 22, Pa.

meyer, who will be in charge of engineering of selenium rectifiers, quartz crystals, transformers and coils, special purpose and transmitting tubes and cables, was formerly chief receiver engineer and staff engineer of RCA Victor Division, RCA.

W. S. WINFIELD, formerly with Colonial Radio, Buffalo, joins Westinghouse Electric Corp. to become chief engineer of the home radio division.

LAWRENCE C. F. HORLE, New York consulting engineer, is appointed chief engineer in the engineering

department of RMA. He will be responsible for management of the department, including the RMA Data Bureau and related activities.

A. D. WILLARD, JR., manager of Radio Station WBT, fills the newly created office of executive vice-president in NAB (National Association of Broadcasters).

ESTERLY CHASE PAGE, until recently a lieutenant colonel, U. S. Army Signal Corps, joins the Mutual network in the newly created post of engineering director. He will head up a new technical planning and engineering department and be responsible for future f-m and television activities as well as improvements on present a-m facilities.

HENRY F. DEVER, vice-president in charge of engineering for Minneapolis Honeywell-Regulator Co.,

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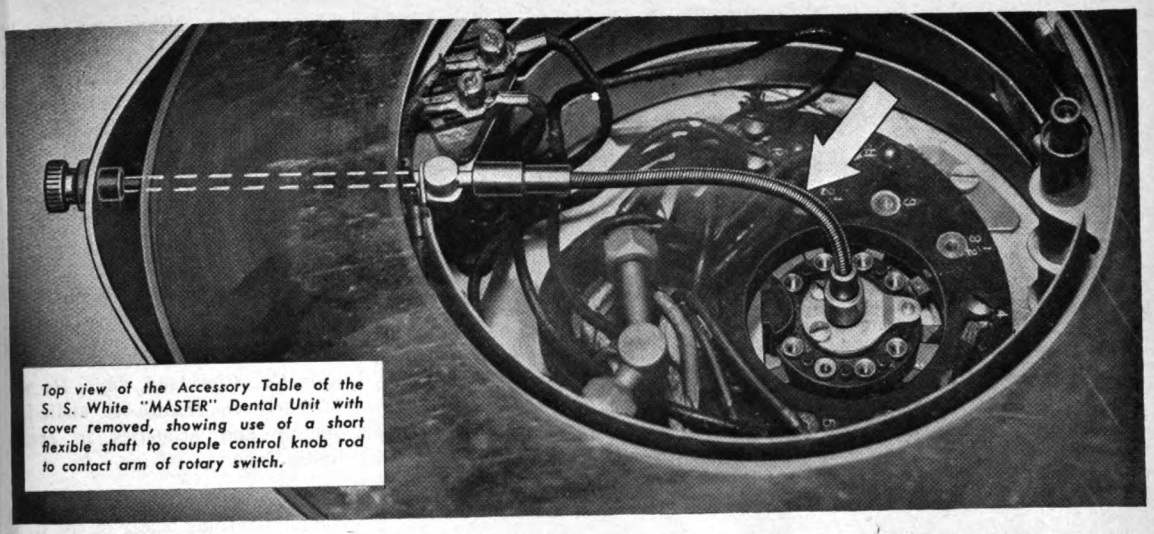
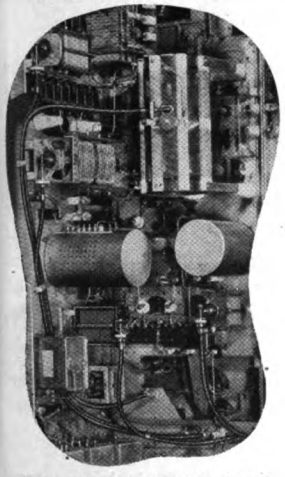


Top view of the Accessory Table of the S. S. White "MASTER" Dental Unit with cover removed, showing use of a short flexible shaft to couple control knob rod to contact arm of rotary switch.

WHEN DESIGNING ELECTRONIC EQUIPMENT

Remember this use of . . . S. S. White Flexible Shafts



That coupling with S. S. White flexible shafts gives complete freedom in placing variable elements is clear from this interior view of a large broadcast transmitter. Note centralized controls.

Electronic Equipment generally includes elements which require rotational adjustment. In designing the internal arrangement, positioning of these elements is determined by considerations of simplification of assembly and wiring, space saving, convenient servicing. At the same time, control knobs or dials must be placed where they will be in ready reach of the operator.

Coupling of the elements to their control knobs with S. S. White flexible shafts is the simple solution. It gives complete freedom of location—as can be appreciated from a look at the applications illustrated. And nothing is lost in the quality of control, for with correct application, S. S. White remote control shafts provide operation that is as smooth and sensitive as a direct connection.

GET FULL INFORMATION ABOUT COUPLING IN THIS FLEXIBLE SHAFT HANDBOOK

This 256-page volume completely covers the subject of flexible shafts, coupling included. It gives all technical data and information essential to working out actual applications. A complimentary copy will be mailed to you if you will write for it on your business letterhead and mention your position.

ARMY (E) NAVY

S. S. WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO. DEPT. E, 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS AIRCRAFT ACCESSORIES
MOLDED PLASTICS
MOLDED RESISTORS FLEXIBLE SHAFT TOOLS

One of America's AAAA Industrial Enterprises

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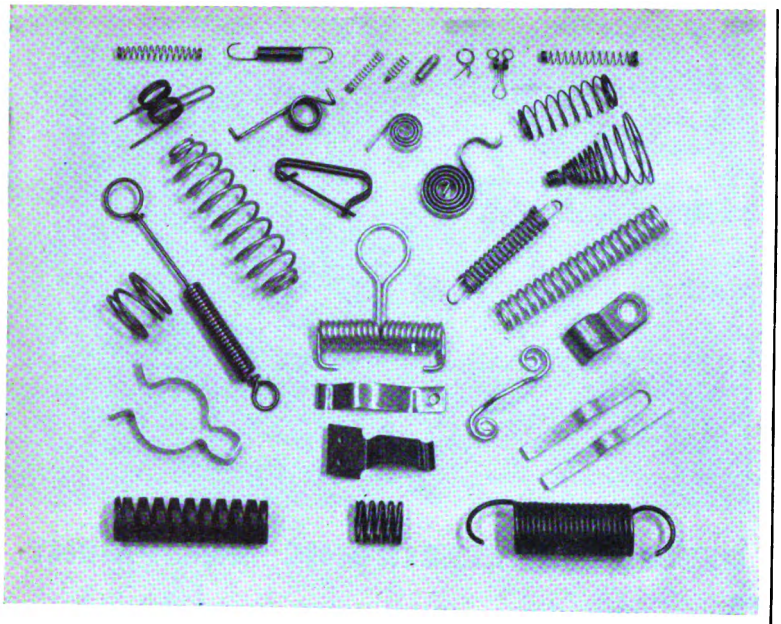

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Reliable

The efficiency of your product—if it requires springs—is highly dependent on the *quality* of those springs. With little or no difference as to *cost*, the service life and performance of your equipment can be radically improved by proper attention to the design, material, and workmanship on your springs.

Reliable is thoroughly experienced on all varieties of springs, wire forms and light stampings, with special emphasis on precision work requiring close tolerances. Our facilities and personnel are exceptional because our kind of customers very often demand exceptional results.

On all-out war production, Reliable has really done things with springs—attained results which we will certainly later turn to good account on your civilian needs. Remember that for experimental springs or small lots, our small order department is at your service. If you're in a hurry—we have the facilities and the materials for double-quick delivery!

Ask for Reliable Catalog 44.

THE RELIABLE SPRING & WIRE FORMS CO.

3167 Fulton Rd., Cleveland 9, Ohio • *Representatives in Principal Cities*

YOU CAN RELY ON

Reliable Springs

ROUND AND FLAT WIRE SPRINGS

CLIPS HOOKS BENDS LIGHT STAMPINGS

Minneapolis, Minn., succeeds Charles B. Sweatt as president of the wholly-owned subsidiary, Brown Instrument Co. He will be replaced by W. J. McGoldrick, vice-president in charge of aeronautical engineering.

PAUL H. FRYE, chief engineer at Electronic Laboratories, Chicago, Ill., has the new title of vice-president.

FRANCES B. SMITH is appointed to the post of chief engineer at the Rola Co., Cleveland, Ohio. He was formerly in charge of audio-frequency and acoustics in Zenith Radio Corp.

E. M. WEBSTER, captain and chief communications officer of the U. S. Coast Guard is promoted to the rank of commodore.

M. L. REDMAN is in charge of the electron microscope field engineering group of RCA Service Co., Camden, N. J. He has been active in the supervision of electron microscope installations.

G. A. BECK becomes manager of the industrial design division in General Electric Co.'s electronics department.

FRANK W. WALTER of the Michigan State Police leaves the presidency of APCO (Associated Police Communications Officers) to become chief communications engineer of Greyhound Corp. He is replaced by Ray Groenier, Madison, Wis.

LOUIS MARTIN is appointed manager of the application engineering section of the RCA tube division.

W. L. EVERITT, chief of the operational research branch in the office of the chief signal officer, has been released from active service to return to his duties as head of the department of electrical engineering at the University of Illinois. He is also president of IRE.

LEROY D. WELD is director of research at the Turner Co., Cedar Rapids, Iowa. Dr. Weld, professor of physics at Coe College, formerly conducted part time research for the company.

ARTHUR C. OMBERG becomes chief research engineer of the Bendix Radio Division, Bendix Aviation

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FARNSWORTH

EXTENDS COMMUNICATION ACTIVITIES

BY ACQUIRING

THE HALSTEAD

TRAFFIC COMMUNICATIONS CORPORATION

WILLIAM S. HALSTEAD, president of the Halstead Company, joins the Farnsworth organization as consultant on radio communications equipment and traffic control, as well as on other phases of Farnsworth's broad electronic developments.

JOHN A. CURTIS, vice president of the Halstead Company and chairman of its management committee, joins the Farnsworth organization as manager of the mobile communications division.

To EXTEND its broad communications activities into the rapidly expanding field of mobile railway and highway communications and control, Farnsworth has acquired the assets of the Halstead Traffic Communications Corporation, including its developments, designs and patents. Key personnel, including William S. Halstead, president, and John A. Curtis, vice president, have joined the Farnsworth staff.

The Halstead organization is a recognized pioneer in this relatively new field of radio communications. It has invented, developed and produced field-tested equipment to provide railroads with modern, unfailing radio communications. It gave the world its first successful highway radio service, including the centralized control of busses, trucks and passenger vehicles.

The Halstead technical staff will establish new headquarters at the Fort Wayne Farnsworth laboratories. The organization will be merged and coordinated with more than two hundred Farnsworth research and development engineering personnel—a staff of scientists and technicians recognized as one of the country's leading technical organizations in the development of television; broadcast transmitters and receivers; radio-phonographs, and the most complicated types of radio and radar equipment for the Armed Forces.

Farnsworth resources, plus its seventeen years of electronic pioneering, its extensive engineering staff, and specialized manufacturing facilities, will strongly augment the outstanding position of the Halstead developments in this field.

FARNSWORTH TELEVISION & RADIO CORPORATION

FORT WAYNE 1, INDIANA

Farnsworth Radio and Television Receivers and Transmitters • Aircraft Radio Equipment • Farnsworth Television Tubes • Halstead Mobile Communications and Control Systems for Rail and Highway • the Farnsworth Phonograph-Radio • the Capehart • the Capehart-Panamuse

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Corp., Baltimore, Md. Formerly assistant chief of operational research in the U. S. Army Signal Corps, he will be responsible for long-term product development and electronic research in radio, radar and television.

HAROLD GOLDBERG becomes research engineer in the Bendix Radio Division of Bendix Aviation Corp., Bal-

timore, Md. He was formerly senior engineer with the Stromberg-Carlson Co.

WILLIAM G. MORAN, superintendent of electronic tube manufacturing at Westinghouse Electric & Mfg. Co., Bloomfield, N. J., is given the company's honorary award—the Order of Merit. His citation is for recognition of pioneering in engineering development and manufacture of radar transmitting tubes.

AWARDS

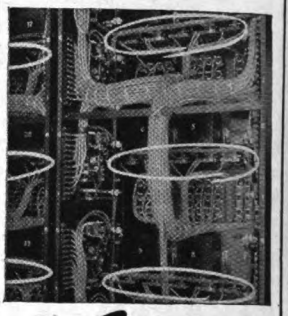
Workers of the following concerns in the electronics field have been awarded Army-Navy burgees for excellence in production:

Federal Telephone & Radio Corp., Newark, N. J.

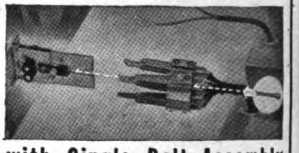
North American Philips Co.
Dobbs Ferry, N. Y.
Mount Vernon, N. Y.

Sylvania Electric Products
Wakefield, Mass.

INACCESSIBLE WIRING?



NOT FOR MODEL MCL AND MODEL MCM "Master" LEVER SWITCHES



with Single Bolt Assembly

EVER run into a problem like the wiring shown above? Or worse? Standard Electric Time Co., Springfield, Mass., did and solved it by using General Control Company's Models MCL and MCM Lever Switches! The Models MCL and MCM have *single bolt assembly* — this means you can attach the switch frame to the panel practically anywhere you like, solder the wiring to the contacts (at a bench, if you wish), then connect the contacts to the frame with a *single bolt*. This feature saves maintenance time too, because the frame can be removed and repaired, or replaced without disturbing the wiring. Write today for New Handbook and Catalog No. 200.

Front view of panel

General Control Company
1202 Soldiers Field Road
Boston 34, Mass.

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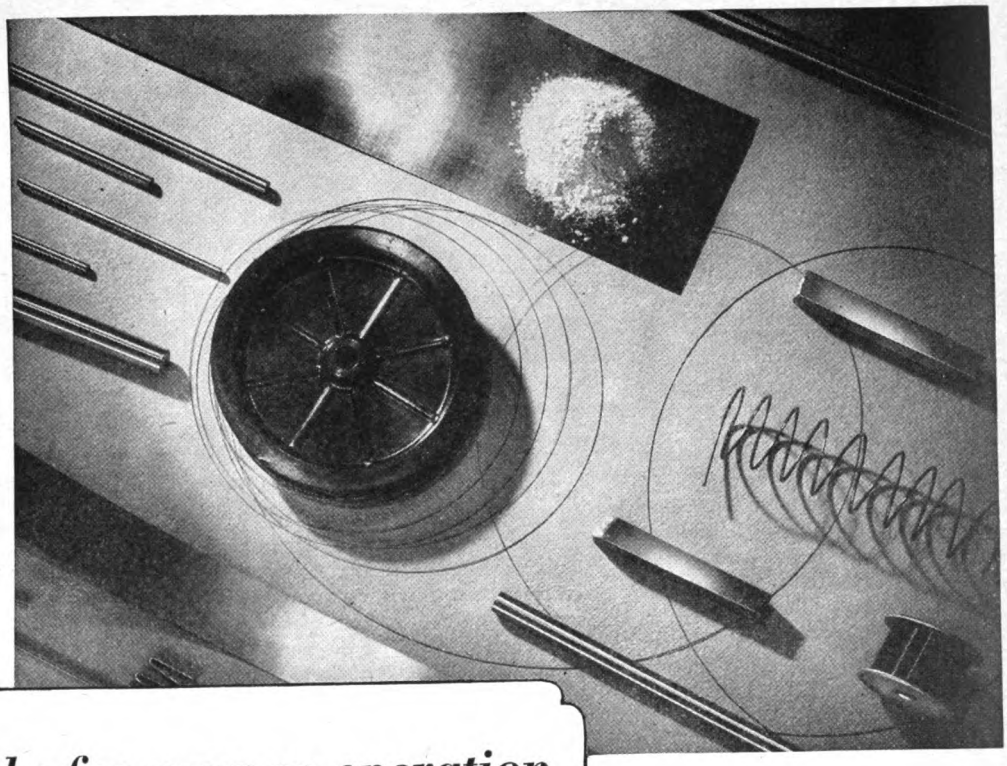

Thanks for your co-operation

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Here's news of interest to you!

As you know, supplies of tungsten and molybdenum products have been limited. During the shortage we tried every means of getting as much of these materials to you as possible. Thanks for understanding the limitations imposed on us and accepting them.

Now we can deliver, *on short order*, most of the tungsten and molybdenum products you need—in rod, bar, wire, sheet or powder form.

Every one of the tungsten or molybdenum products supplied by North American Philips is backed by the knowledge of processes and techniques developed by an organization with a background of over half a century in the electrical field. Every piece of material is controlled to your most rigid specifications.

North American Philips can supply your needs in a variety of sizes, shapes and thicknesses and deliver on short order.

So, when you want tungsten or molybdenum rod, bar, wire, powder, or sheet stock—write, wire or telephone North American Philips. And remember, the services of our application engineers are also at your disposal.

Norelco *Electronic Products by*

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OTHER PRODUCTS: Quartz Oscillator Plates; Cathode Ray Tubes; Searchray (Industrial X-ray) Equipment; X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Fine Wire; Diamond Dies. • We invite you to visit our office and showroom when in New York City.

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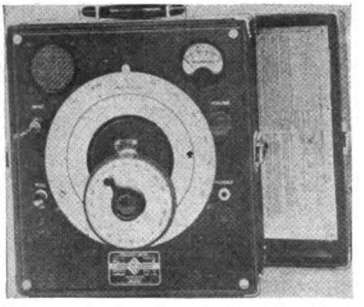
NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

Heterodyne Frequency Meter

TYPE 720-A HETERODYNE frequency meter is a compact, portable, battery-operated instrument for frequency measurements between 10 and 3000 mc. The internal oscillator covers a frequency range of 100-200 mc. For frequencies below 100 mc harmonics of the unknown frequency are made to produce beats with the internal oscillator. For



frequencies above 200 mc harmonics of the internal oscillator product beats with the unknown frequency. The internal oscillator uses a butterfly-type circuit in which capacitance and inductance are varied simultaneously. No sliding contacts are used in this circuit and no current is carried by the bearings; consequently, smooth and stable adjustment of the frequency can be made over the frequency range of the instrument.

The detector is a silicon crystal so mounted that it is easily accessible for replacement. A three-stage audio amplifier is included, having a band width of 50 kc. The output of the amplifier operates a panel meter and a built-in loudspeaker. A jack is provided for head telephones.

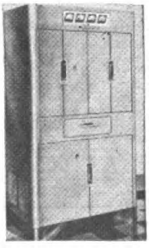
The entire assembly is completely self-contained. Sensitivity of the instrument is high and no direct connection to the source under measurement is required. The pickup obtained by the adjustable antenna (mounted on the panel) is usually adequate, but provision is made for connecting an additional pickup wire. Tubes and batteries are supplied with the instrument. Overall dimensions are 12½ x 13½ x 10½ in. The unit weighs 27¾ lb, with battery, and is priced at $250.

General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Ground Station Transmitters

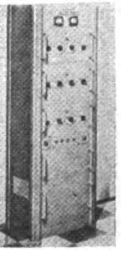
TWO TYPES OF GROUND station transmitters are available from Bendix Radio, Baltimore, Md.

The first of these is described in Bulletin No. SE-113 and is designated as Model TG-15. It is a me-



dium-power transmitter for operation in the low-frequency (200-540 kc), high-frequency (2.5-15 mc), and very high-frequency (118-132 mc) bands. It can be operated on four separate channels in any combination of these frequency ranges, and, as the separate r-f units are mechanically interchangeable, it is easy to modify the transmitter for a different frequency arrangement should requirements change while the unit is in service. The h-f unit is capable of operation on two adjacent channels, the vhf unit on three, making it possible to pretune as many as 12 frequencies on the same transmitter. Either radio telephone or radio telegraph operation may be used with l-f and h-f units while radio telephone only is available on the vhf unit. Power output for continuous commercial service in the low and high-frequency ranges is 500 watts and over 300 watts in the vhf range.

The second type of transmitter is described in Bulletin No. SE-114, and is designated as TG-16. Low-



frequency (beacon and control tower), high-frequency (airways communications), as well as very high-frequency (proposed band for all aircraft service) operation are all available in one transmitter with power outputs ranging from 100 watts at vhf to 190 watts at the lower frequencies. Individual and interchangeable r-f sections make possible a high degree of flexibility. Up to four such sections can be operated by a single control unit, and each h-f and vhf section may be pretuned for operation on either of two adjacent channels. If l-f operation is not required, it is possible to operate the transmitter on any one of eight pre-tuned channels using only four r-f sections and one control unit in addition to the power supply and modulator. The equipment is designed for continuous operation at ambient temperatures between −40 and +50 C, and relative humidities between zero and 95 percent.

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DeJUR

MODEL 120 . . . A New DeJUR Miniature Meter . . . precision instrument for more permanent accuracy in small panel space. Conforms to forthcoming JAN-1-6 specification . . . self-contained up to 1 ampere and 150 volts. D.C. or A.C. (rectifier) . . . external shunts or multipliers . . . in a wide variety of ranges.

ALNICO MAGNETS . . . highest grade . . . provide stability and quick response under high torque, with increased protection against magnetic fields.

EXTERNAL PIVOTS . . . insure maximum accuracy . . . reduce pointer-rocking, side friction between jewels and pivots, and wear on bearing surfaces.

EXTRA-TIGHT SEALING . . . completely waterproof . . . in addition, rubber gasket seals flange to panel. Model 120 is particularly adapted for water-proof equipment.

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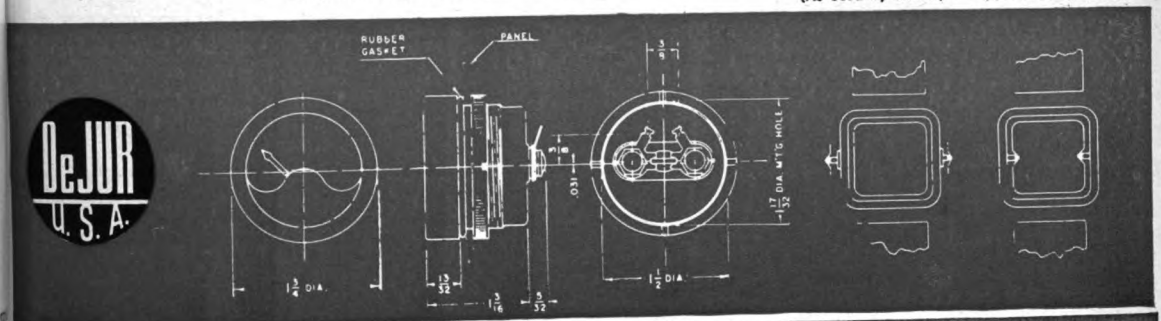
Compact, Trouble-Free Modern Design

External Pivot (As Used by DeJUR)

Internal Pivot (Not Used by DeJUR)



AMMETERS . . . VOLTMETERS . . . POTENTIOMETERS

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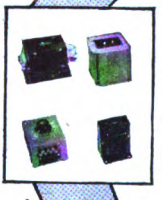

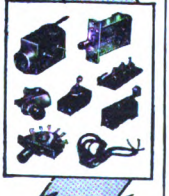

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Radio and Electronic Supplies

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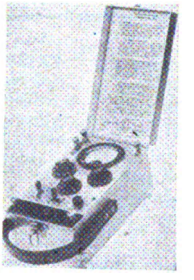
Lineman's Bridge

SMALL, RUGGED and compact enough to be carried easily, this bridge (measures 9 x 5 x 4½ in. and weighs 5 lb complete) is built to meet the requirements of the telephone and telegraph lineman. It is used to measure the resistance of wires as well as the unbalance between two wires. It can also be used as a general purpose bridge up to the limit of its capacity. By throwing a switch and changing the position of



the three decade dials the reading on the loop can be changed to the unbalance reading without disturbing the connections. The switching arrangement also designates which wire has the higher resistance. The range of the measurement is up to 111 ohms in steps of 0.1 ohm with an accuracy of one-quarter of 1 percent. The galvanometer (Weston Model No. 375) has a sensitivity of approximately 22 μa per division for 30 divisions. Batteries are standard 1½-v flashlight cells arranged so that they can be quickly and easily replaced. Nilsson Electrical Laboratories, Inc., 103 Lafayette St., New York 13, N. Y.

Brown Instrument Devices

A CHART-DRIVE CONTROL, embodying means for automatically starting and stopping electronic-recorder chart motion by pen position is available from Brown Instrument Co., Philadelphia, Pa. for their circular chart designated as "ElectroniK" recorder. Control contacts are wired in the chart drive circuit. By setting the control point, the chart can be stopped and started as desired, corresponding to any pen position. The new feature is useful in molten-metal thermocou-

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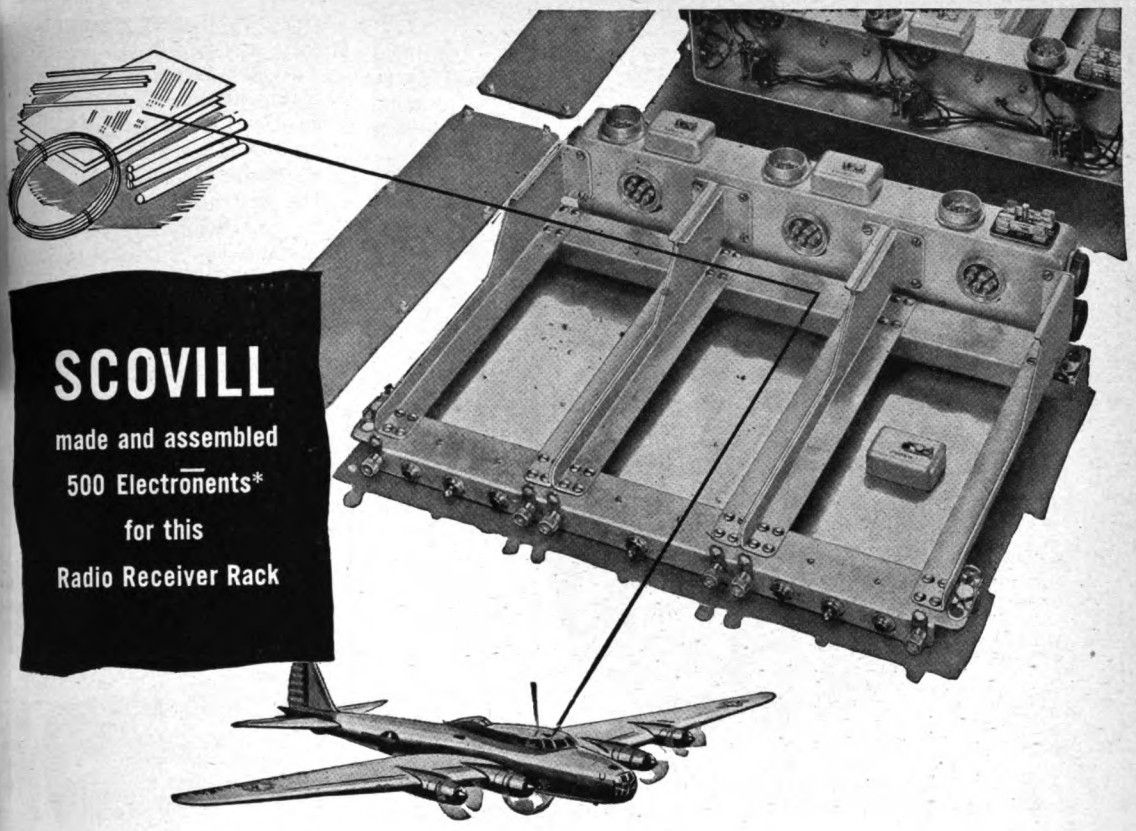

SCOVILL

made and assembled
500 Electronents* for this
Radio Receiver Rack

Demonstrating how Scovill can reduce your overhead on small parts or complete assemblies

Put yourself in the shoes of the prime contractor who needed this three-position, high-frequency radio receiver rack for big bombers in a hurry. He could have undertaken to make in his own plant the more than 500 individual parts required, or . . . made some and purchased the remainder, then assembled the complete unit himself. Instead he turned the complete responsibility over to Scovill . . . and saved time, space, trouble and money.

Here's what Scovill did: made all the metal parts of sheet, rod, wire and tube stock using such metal-working methods as forging, stamping, drawing, heading, machining and wire forming . . . cut all wires to length, stripped and soldered them into position . . . manufactured, tested and adjusted relays . . . assembled the entire rack as illustrated.

Investigate how Scovill's versatile production setup, as exemplified above, can improve the quality or lower the cost of your small electronic components or complete assemblies. Learn how Scovill's designing and metal-working experience and facilities will make you sure of getting the one *right* solution to your metal-parts problems. For proof of Scovill's ability to help you, write for literature. Fill in the coupon below and mail it today.

*Electronents = Electronic Components

Scovill
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WATERBURY 91, CONN.

Please send me a free copy of "Masters of Metal" booklet describing your facilities. I am interested in the ELECTRONENT* applications checked.

- ☐ Batteries
- ☐ Record Changers
- ☐ Clips
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- ☐ Dials
- ☐ Escutcheons
- ☐ Jacks
- ☐ Lugs
- ☐ Panels
- ☐ Sockets
- ☐ Stampings (misc.)
- ☐ Tubes

Other applications.....

SCOVILL MANUFACTURING COMPANY

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Company .....

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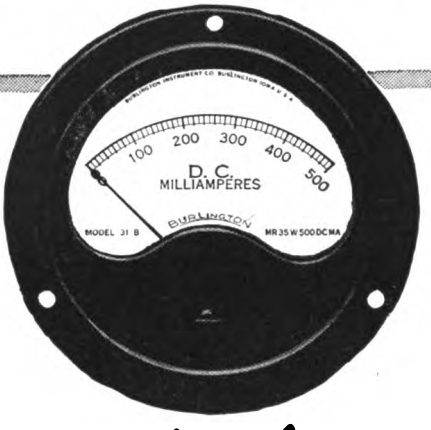
Burlington

PANEL INSTRUMENTS



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Due to design characteristics and close control of manufacturing processes, Burlington instruments embody the following advantages:

PERMANENCE OF CALIBRATION . . . All DC instruments employ Alnico magnets which are known to be more highly resistant to shock, heat, vibration, and stray fields than any other magnetic material.

FREEDOM FROM STICKING . . . Clearances for all moving parts are such that the results of entrance of small particles as encountered in field service are reduced to a minimum.

STABILITY OF OPERATION . . . All instruments are "NORMALIZED" after assembly to eliminate "zero shift" and other calibration errors due to ageing.

Exceptionally high torque to weight ratio of control springs to moving element insures minimum error under conditions of shock, vibration, and other rough usage.

Alignment of jewels and magnet core piece is such that the center lines of these parts coincide within plus or minus .002". The design of the brass movement frame and components is such that mechanical tolerances are reduced to a minimum in assembly. As a result, jewel and pivot wear is uniform which reduces "frictional torque" of the moving coil.

All series resistors and coils are heat treated and impregnated after wrapping to insure stability and long life.

All ranges AC & DC are available in 2½", 3½" and 4½" sizes, both square and round, flush mounting.

Engineering service furnished for specialized applications. No obligation. Write today for further information.

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102 FOURTH STREET
BURLINGTON, IOWA

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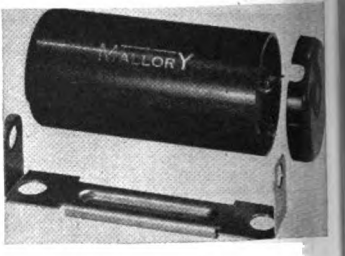
PANEL INSTRUMENTS • VOLTAGE REGULATORS • AUTOMATIC SYNCHRONIZERS • FREQUENCY REGULATORS

ple and radiation pyrometer applications.

A new safety emergency alarm feature that protects process equipment and materials has been added by Brown Instrument to its line of electronic air-operated controllers. The instrument is designated as ElectroniK contact controller and it provides on-off control in addition to air control to actuate motorized valves, solenoid valves, contactor panels, signal lights, etc.

Capacitor Mounting Bracket

FASTER, LESS expensive assembly of capacitor motors is facilitated by the use of a new plastic capacitor and mounting bracket developed by P. R. Mallory & Co., Inc., Indianapolis, Ind. The bracket is used with the new Mallory type P



plastic case capacitor and end cap. The bracket requires no special tools since it is fastened to the motor with two screws. The capacitor is snapped into the bracket by hand. Two different lengths of brackets (which will handle four capacitor case sizes) are available. The unit is splash-proof and moisture-proof.

Variable Isolation Transformer

ISOLATION-TYPE transformers (designated as type W Vari-Formers) are a new development of the Gulow Corp., 26 Waverly Place, New York 3, N. Y. They are double or isolation wound for laboratory and industrial use. The units have a primary wound for 115-v input and a variable secondary wound for an output of 0-130 volts. Separate terminals are provided for both primary and secondary windings. The units can be connected as auto

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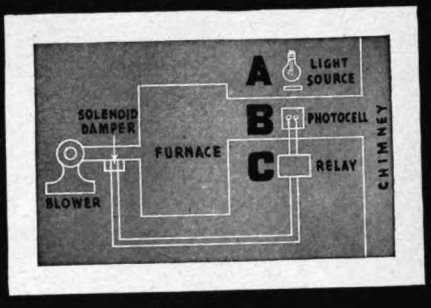

How to stop smoking with smoke

Typical of the applications possible with a Bradley Luxtron* photo*cell* is this suggested means of smoke control in a stoker-fired furnace.

Light source "A", beamed through the smoke stack to photo*cell* "B", will cause the cell to generate power sufficient to close relay "C" until smoke diminishes the light. Or the system could be arranged to close the relay when light is reflected by smoke particles.

In any event, resistance to vibration and temperature changes make the photo*cell* ideal for such an application. As in any photo*cell* application, it is as simple as A, B, C—and the "B" stands for Bradley.

Write Bradley for literature and complete engineering assistance on any photo*cell* application you may have in mind.

Write for Rectifier Data

Bradley also has available a complete line of unique copper oxide rectifiers, featuring mounting flexibility, pre-soldered terminals for ease and safety in assembly, low forward resistance with high leakage resistance, and gold coating of pellets to provide long life.

Data on five basic models are included in an illustrated Bradley "Coprox" Rectifier bulletin sent on request. Please write for it.

*TRADE MARK REG U S. PAT. OFF.

PHOTOCELLS—MASTERS OF LIGHT **BRADLEY** MASTER OF PHOTOCELLS

BRADLEY LABORATORIES, INC., 82 MEADOW STREET, NEW HAVEN 10, CONNECTICUT

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Standard fixed resistors: 10 and 20 watt; 1-50,000 and 1-100,000 ohms.

Standard adjustable resistors: 25 to 200 watt; 1 to 100,000 ohms. Additional sliders available.

Also other types of terminals and mountings.

It's a GREENOHM!

★ Yes, it's a Greenohm—not just another power resistor.

And that means a lot to you and the buyers of your products. It means a tougher, longer-lasting, absolutely dependable power resistor.

Greenohms are those green-colored cement-coated power resistors featured in the finest transmitters and receivers; in power supplies; in electronic, electrical and industrial equipment. Already in service year after year since they were first introduced, Greenohms have proved that "they can take it"—and then some. No tougher resistors are made.

Try a Greenohm! Make your own comparative tests. Then draw your own conclusions once and for all.

★ Greenohms are available in standard sizes and values through local jobbers. For volume requirements or special types, write us direct.

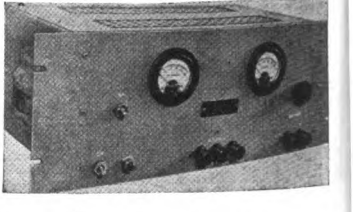
CLAROSTAT Controls and Resistors

CLAROSTAT MFG. CO., Inc. · 285-7 N. 6th St., Brooklyn, N. Y.

transformers to obtain several different voltage combinations. Inputs of 115 or 220 volts can be applied and output voltages of 0-65 or 65-130 are obtainable with increments of 0.3 volts. Output ranges of 0-130 or 115-245 volts with increments of 0.6 are obtainable. The separate primary and variable secondary windings are wound on the same core eliminating the need of two transformers to obtain an isolated variable voltage supply. For critical electronic testing and special applications, an electrostatic shield has been imposed between the windings, grounded to the core and brought out to a separate terminal. These units are available with capacities of 500 va to 2000 va.

Power Supply

MODEL 200-B IS a new and improved power supply for applications in the laboratory and on the production line. Its characteristics are:



Voltage, from zero to 325-v d-c at 125 ma continuously variable, and 6.3-v a-c at 6 amp, center tapped; Regulation, within 1 percent for voltages between 20-235 volts from no load to full load. Within 2 percent at 10 volts from no load to full load; Hum voltage, less than 10 mv including noise; Metered output, voltmeter and milliammeter included to read output voltage and current. Electronic Measurements Co., 10 West Front St., Red Bank, N. J.

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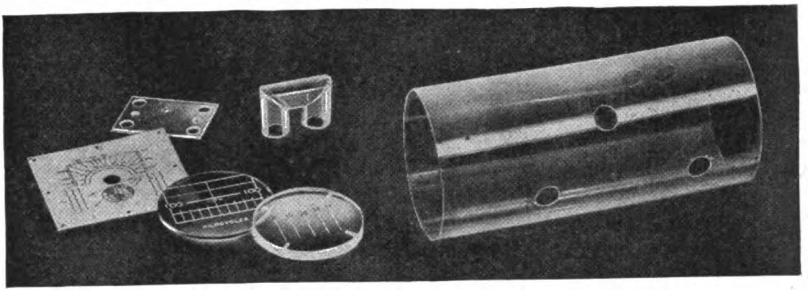
PLASTIC PARTS

. . . . PRODUCED TO YOUR SPECIFICATIONS

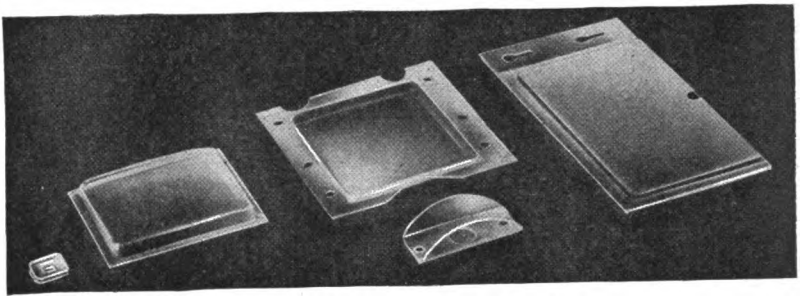
PRINTING
DIE CUTTING
CEMENTING

Wide experience by all known processes in the application of printing, engraving, silk screening, die cutting and cementing of all thermoplastics.



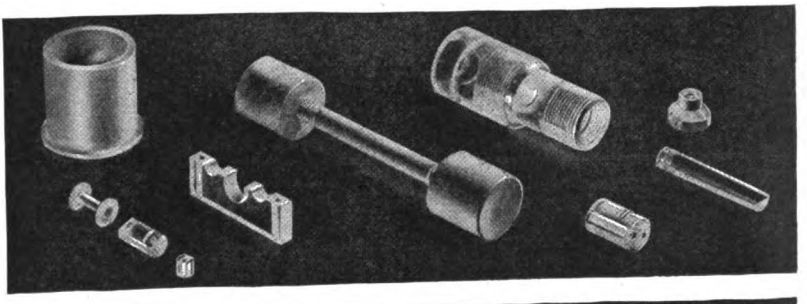
FORMING

Specialists in deep drawing radio dial windows, embossing, swaging and bending in Acetate, Vinylite and Acrylics.



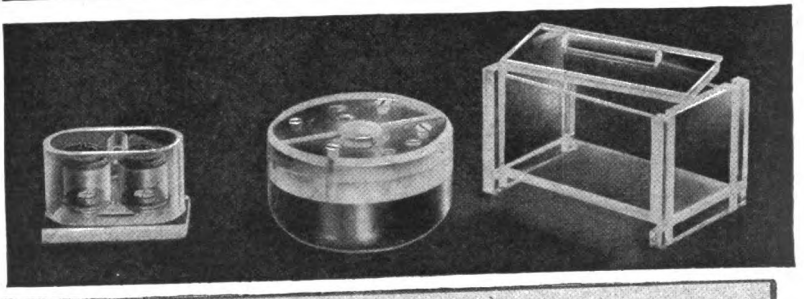
MACHINING

Precision threading, screw machine, milling, drilling, turning of Polystyrene, Acrylics, Phenolics, Nylon, Tenite; sheets, tubes and rods; through spindle capacity up to 2½" rod.



ASSEMBLY

Our engineers can assist you in problems of design and assembly of your plastic units.



PRINTLOID, *Inc.*

93 Mercer Street
New York 12, N. Y.

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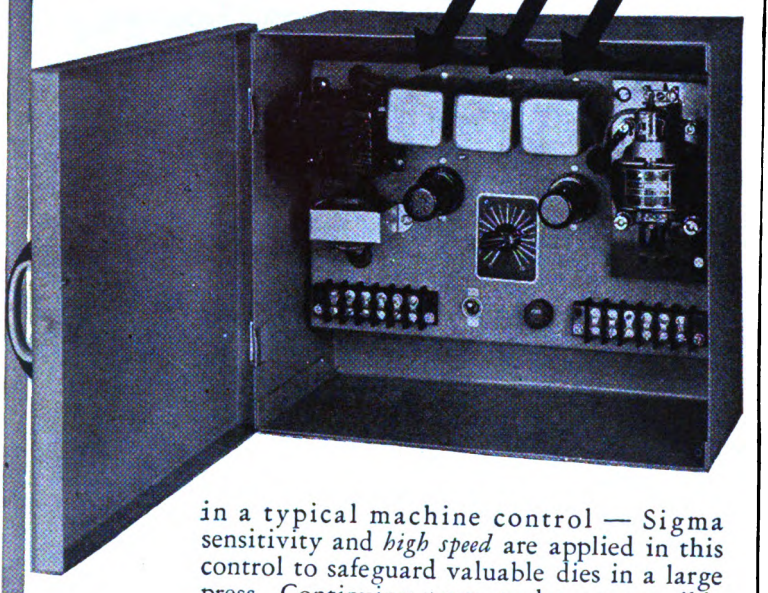
here are 3 SIGMA RELAYS



in a typical machine control — Sigma sensitivity and *high speed* are applied in this control to safeguard valuable dies in a large press. Continuing press cycles are possible only as each formed piece is ejected and monitoned by the control.

SIGMA RELAYS have always embodied —	
Speed	Sensitivity
Long Life	Compactness
Stability	Precision

Now is the time to let our Engineering Department know what additional specific features will be required in relays for your product. We intend to design new relays for expressed demands first. Do you need —

- Multicircuit Contacts?
- Higher Power Handling Capacity?
- Polarized Relays?
- Differential Operation?
- Snap-Action Contacts?
- A-C-relays?

Write and let us know the relay features which would be specifically useful to you, *especially those not now obtainable in existing relays.*

SIGMA

Sigma Instruments, INC.

Sensitive **RELAYS**

62 CEYLON ST., BOSTON 21, MASS.

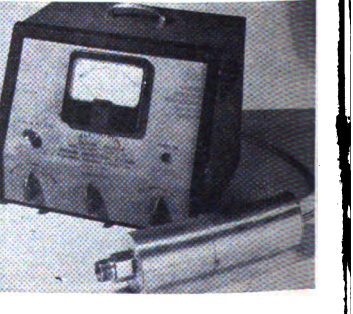
Oscillator

TYPE 291 IS A portable, battery-operated oscillator especially designed for checking high-frequency aircraft radio receivers. The unit has a frequency range from 49 to 154

mc with modulation frequencies of 70, 90, 400, 1300 and 3000 cycles. It contains an easily extended, collapsible antenna and two coaxial terminals for low and high-level outputs. Andrew Co., 363 East 75th St., Chicago 19, Ill.

Ionization Gage

THE ALPHATRON is an all-metal ionization gage with continuous linear response to 10-mm total pressure. The ionizing agent is a stream of alpha particles emitted by a radioactive source, which permits operation at any pressure, including atmospheric, without damage to



the gage. The steady emission characteristic of the radioactive element and amplifier design insure stability and reduce needle flicker to a minimum. The model produced at present by the National Research Corp., Vacuum Engineering Div., Boston 15, Mass., covers from zero to 10 mm in three ranges, all reading direct pressure. The ranges are zero to 0.1 mm, zero to 1 mm, and zero to 10 mm. Pressures are read to 1 percent of full-scale reading.

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POSTWAR TRANSFORMERS
BY
FOSTER

Facilities for peacetime manufacture of transformers are already available at A. P. Foster, and, as war commitments are filled, will be increasingly at your service.

During the war years A. P. Foster has supplied thousands of custom-designed and custom-built transformers to all branches of our armed services, for use in all parts of the world under great extremes of climatic condition.

High production schedules have been maintained by advanced Foster manufacturing techniques. High standards of performance were demanded, achieved and will be maintained—to the benefit of America's peacetime economy.

As your own reconversion plans advance from the conference stage to the blueprint stage, it may well be worth your while to bear in mind that Foster engineers and designers are ready *now* to consult with you on every transformer problem and to furnish estimated costs and delivery schedules on experimental or quantity production of standard transformers or special jobs custom-built to your own specifications.

- BOB REID, 810 West 57th Street, Indianapolis 5, Ind., Telephone Broadway 2725
- BAUMAN AND BLUZAT, 2753 West North Avenue, Chicago 47, Ill., Telephone Humbolt 6809-10-11-12
- THE A. P. FOSTER COMPANY, BARRETT BORDER, 11 W. 42nd St., New York 18, N. Y., Telephone PEnnsylvania 6-9133

SPECIALISTS IN BUILDING TRANSFORMERS SINCE 1938

A. P. FOSTER COMPANY

TRANSFORMER ENGINEERS & MANUFACTURERS

719 WYOMING AVENUE, LOCKLAND 15, OHIO (SUBURB OF CINCINNATI)

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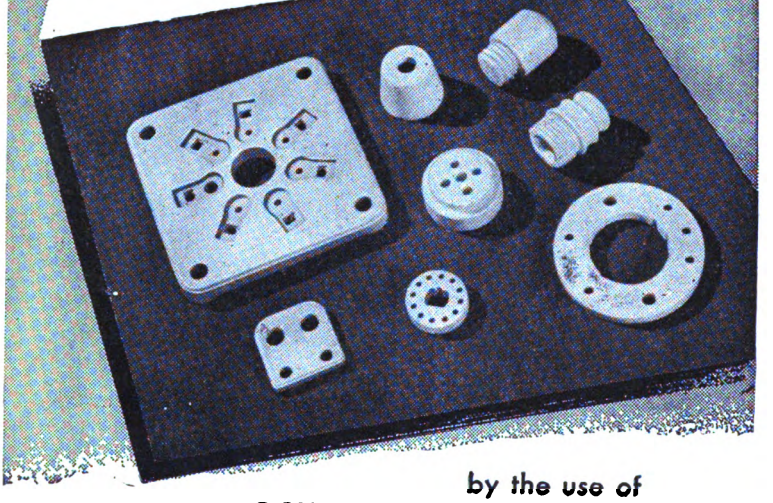
A New Impregnating Service

Which . . . PROTECTS STEATITE CERAMIC PARTS AGAINST MOISTURE ABSORPTION AND FUNGUS ATTACK . . . . . .



by the use of

DOW-CORNING FLUID #200

This new method for waterproofing ceramic surfaces results in increased electrical resistance and improved performance of equipment under conditions of high humidity and condensation. Application of Dow-Corning Fluid No. 200 to ceramic bodies coats them with an extremely thin film of silicone. It will adhere effectively even when immersed for days in sea water and does not collect dust or corrode metals; nor will it react with organic materials. It has a power factor of the order of .005% and is effective up to 150°C. It also acts as a neutral flux for soldering, and is not removed by contact with organic solvents. For further applications and engineering data write or phone.

Other Services:
- DEHYDRATING
- DIPPING
- IMPREGNATING
- CENTRIFUGING
- SPRAYING
- POLISHING

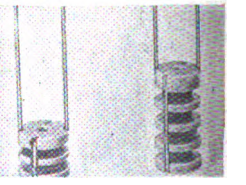
PRODUCTION ENGINEERING CORP.

666 VAN HOUTEN AVENUE, CLIFTON, N. J. • TEL. PASSAIC 2-5161

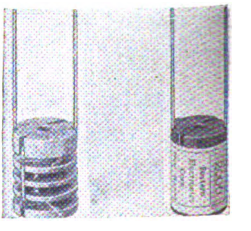
The gage is suitable for measuri pressures of gases other than a such as argon, water vapor, a hydrogen, as the linear response the gage hold true regardless of t atmosphere.

Resistors

EASTERN ELECTRONIC Corporatio (41 Chestnut St., New Have Conn., manufacturers of precisio wire-wound resistors, wheatston bridges, radio and electronic te equipment and radar assemblie announce "Korect-Ohm" resisto as follows: Type CC, low-temper



ture coefficient, has a maximum r sistance of 250,000 ohms; Type N has a maximum resistance of 500 000 ohms; Type NA has a maxi mum resistance of 1 million ohms; Type CA ranges from a few ohm to 500,000 ohms; Type CB has



maximum resistance of 500,000 ohms; and finally Type NB which has a maximum resistance of 1 million ohms. All resistors are aged and treated to relieve strains due to winding before the final adjustment is made. Final resistance adjustment accuracy is rated to better than 0.1 percent. The resistors are wound with an alloy wire having a resistance change vs temperature of less than 0.08 percent between −55 and + 55 C. For applications where space is a factor, resistors are wound with an alloy wire having a resistivity of 650 ohms per circular mil ft. The resistance change vs temperature is 0.5 percent plus or minus between −50 and + 50 C.

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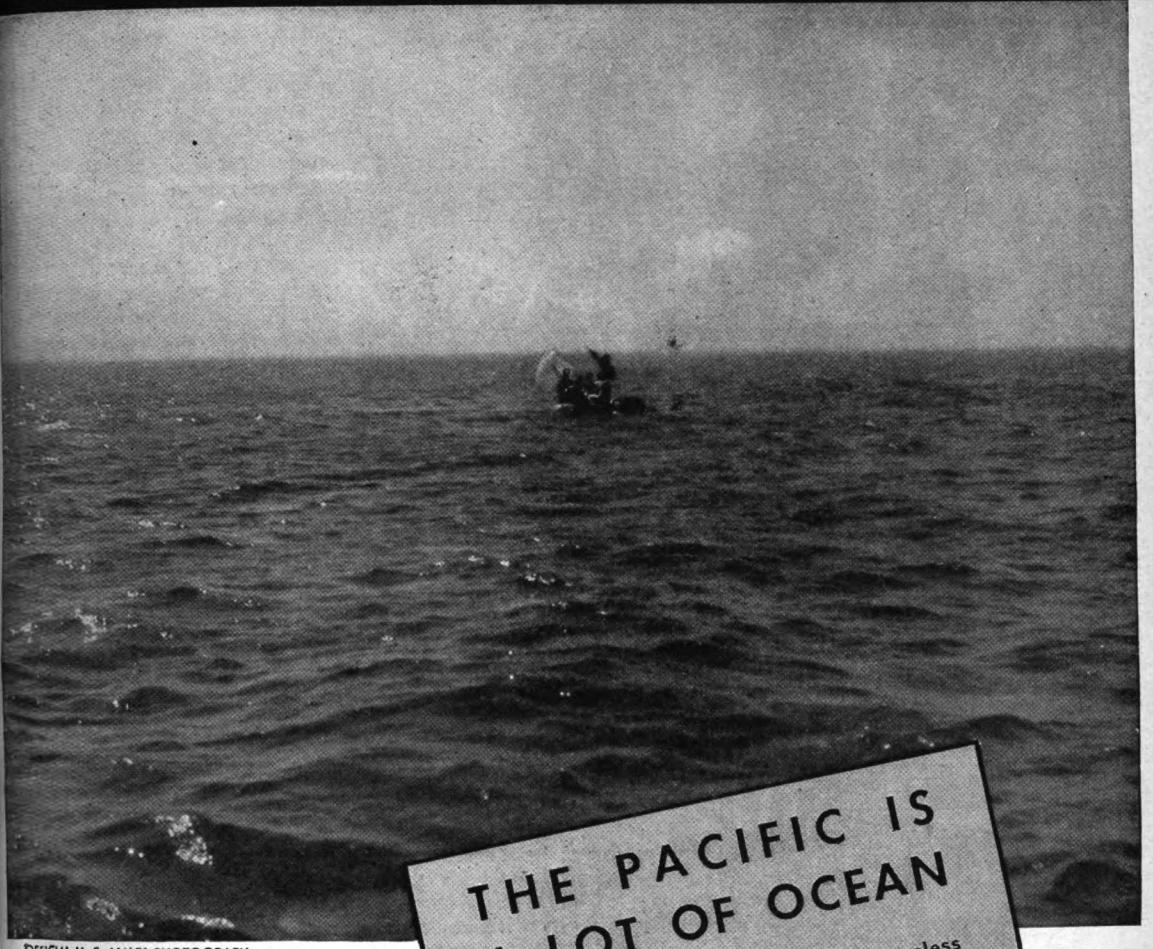
NATIONAL RECEIVERS ARE THE EARS OF THE FLEET



OFFICIAL U. S. NAVY PHOTOGRAPH

THE PACIFIC IS A LOT OF OCEAN

It is a big place to get lost in. The ceaseless search by Navy PBM "Mariners" has saved the lives of many downed fliers. Sometimes the plane can make the rescue; often radio sends help on its way.

The Navy knows how important radio equipment is. 3 out of 4 of the Navy's ships — landing craft and larger — use receivers designed by National.

HRO

NC-200

NATIONAL COMPANY

MALDEN MASS, U. S. A.

NATIONAL RECEIVERS ARE IN SERVICE THROUGHOUT THE WORLD

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For more than 10 years

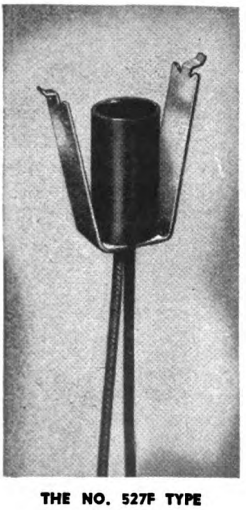
we have been manufacturing crystals. Not only are we crystal manufacturers, but crystal specialists as well. Consult us on your "crystal problems".

★

PETERSEN RADIO CO.

Council Bluffs, Iowa

CRYSTALS EXCLUSIVELY SINCE 1934



THE NO. 527F TYPE

Check the Quality Features of the Drake No. 500 Series

- √ Time tested — *Millions have been used since March 1940!*
- √ Available in *any* quantity with *any* type of bracket.
- √ Sturdy Bakelite Molded insulating casting shields socket from outside contact.
- √ Center contact lead wire mechanically secured before soldering.
- √ Both lead wires withstand over 25 lbs. tension.
- √ Rounded eyelet edges prevent cut or frayed lead wire insulation.
- √ 1000 volts minimum breakdown voltage between contacts and to ground.
- √ Casting mechanically secured to bracket — can't turn.
- √ Socket mechanically secured within casting — can't turn or be pulled out.
- √ Center contact secured within socket— contact won't protrude when lamp removed.

Consider this better underwriters' approved DRAKE dial light assembly for war or peace-time products. Lead wire 2¾ in. to 4 ft. Prompt shipment in any quantity assured. May we send samples or our newest catalog?

DRAKE

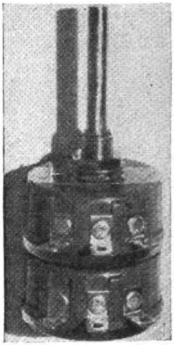
SOCKET AND JEWEL LIGHT ASSEMBLIES

DRAKE MANUFACTURING CO.

1713 WEST HUBBARD ST., CHICAGO 22, U. S. A.

Wire-Wound Potentiometers

TREFZ MANUFACTURING CO., 38-11 Main Street, Flushing, N. Y. announce Series PWW-5 wire-wound potentiometers which have been produced to Army and Navy specifications for electronic operations. The linearity of both single and dual units makes them readily adaptable to applications using calibrated dials or in circuit arrangements where close series of parallel tracking is a requirement. Wattage rating is high for a standard-size unit (patent pending feature). An electronically-welded instrument spring maintains positive continuity between center terminal and wiping contact. A dust-proof phenolic case houses the units, and



when specified, a sealing washer can be furnished between the case and the heavy cover making a hermetically-sealed potentiometer when used in conjunction with a water tight panel bushing. Resistance range is rated 1 ohm to 150,000 ohms; shafts are made to specification; switches can be supplied in off position and tapered units.

Magnetic Phonograph Pickups

NEW LOW COST magnetic phonograph pickups, produced by Caltron Company (11746 W. Pico Blvd., Los Angeles 34, Calif.) have a smooth response to 6000 cps and a sharp cutoff beyond top frequency. Units have no bearings, pivots or needle chucks. The manufacturer states that units will track fully modu-

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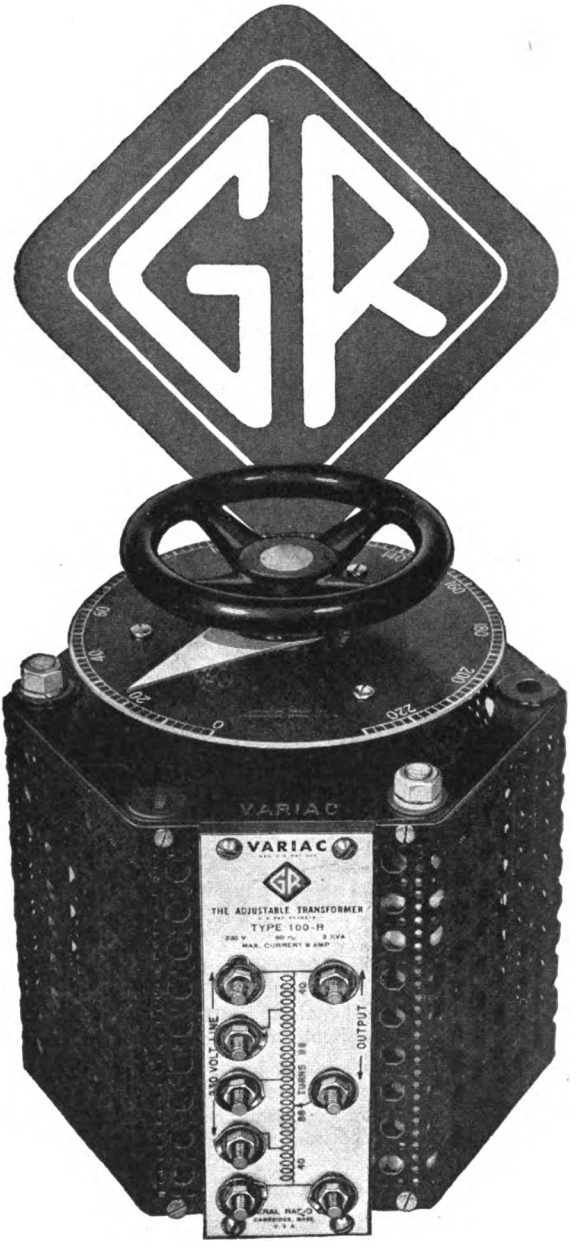
MORE VARIACS* NOW!

A portion of our greatly expanded VARIAC production has been released from war orders. VARIAC deliveries are improving daily. We hope that within a comparatively short time *all* models of the VARIAC can be shipped promptly upon receipt of your order.

In the meantime you'll find several weeks required for delivery of some models well worth the waiting . . . VARIACS are still the *original* continuously-adjustable autotransformer first introduced by General Radio . . . redesigned to meet all of the mechanical and electrical requirements for all types of service . . . assuring rugged construction, long life and the same manufacturing care that is given to the finest G-R laboratory instrument.

You may have to wait a little longer for VARIACS, but you'll be satisfied many times longer.



YOU CAN GET THESE FROM STOCK At the moment we have a small stock of the popular Types 100-Q and 100-R VARIACS and can ship immediately. These models are rated at 2,000 va. The Type 100-Q supplies continuously adjustable voltages from zero to either 115 or 135 volts from a 115-volt 60-cycle line with a maximum output of 18 amperes; the Type 100-R supplies a maximum of 230 or 270 volts from either a 230- or 115-volt line with a maximum current rating of 9 amperes from a 230-volt input, or 4.5 amperes when used on 115 volts. Price of either model: $40.00.

The trade name VARIAC is registered at the U. S. Patent Office. VARIACS are manufactured and sold only by General Radio Company under our U. S. Patent 2,009,013.

VARIAC

E ONLY BY

GENERAL RADIO COMPANY

Cambridge 39, Mass.
NEW YORK
CHICAGO
LOS ANGELES

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For Planning of
RADIO COMMUNICATIONS
investigate
ERCO'S COMPLETE ENGINEERING SERVICE

ERCO'S specialized knowledge and technique is reflected in custom-built equipment for such varied users as Pan American Airways, American Airlines, General Motors, Eastman-Kodak, Grumman, Sperry, National Carbon, Westinghouse, and the Hudson's Bay Company.

Whatever your requirements . . . police, airline or industrial; mobile, ground to air, base to branch, office to field . . . ERCO provides complete service in the design, manufacture and installation of equipment that is engineered specifically to meet YOUR needs. We invite your inquiry.

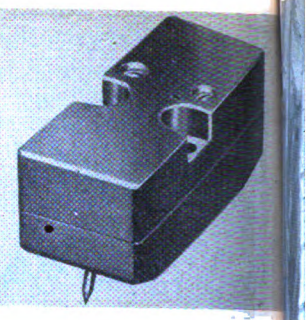
A complete, ERCO-BUILT Radio Station all in one package.

Erco's Engineering staff is available to fulfill your requirements.

ARMY E NAVY

ERCO

ERCO RADIO LABORATORIES INC
HEMPSTEAD, NEW YORK
Manufacturers of CUSTOM BUILT RADIO APPARATUS



lated pressings with 15 grams ne dle pressure. The pickups are no affected by temperature or humid ity, and no scratch filter is needed in the amplifier.

Autoflight Instrument

A MICROTORQUE potentiometer, quiring negligible force to opera is shown coupled to a pressure ga It can be used to remotely indic pressure, to operate alarm signa cut off switches, and for a varie of other devices. This autoflight in

strument, now available for com mercial uses, was originally deve oped for the accurate transmissio of data on board aircraft by G. M. Giannini & Co., Inc., 161 E. Cal ifornia St., Pasadena, Calif.

Double-Beam Cathode-Ray Tube

TYPE 5SP double-beam cathode-ray tube produced by Allen B. DuMont Laboratories, Inc., of Passaic, N. J., provides two complete guns in a single 5-in. glass envelope, both aimed at or converging on the sin-

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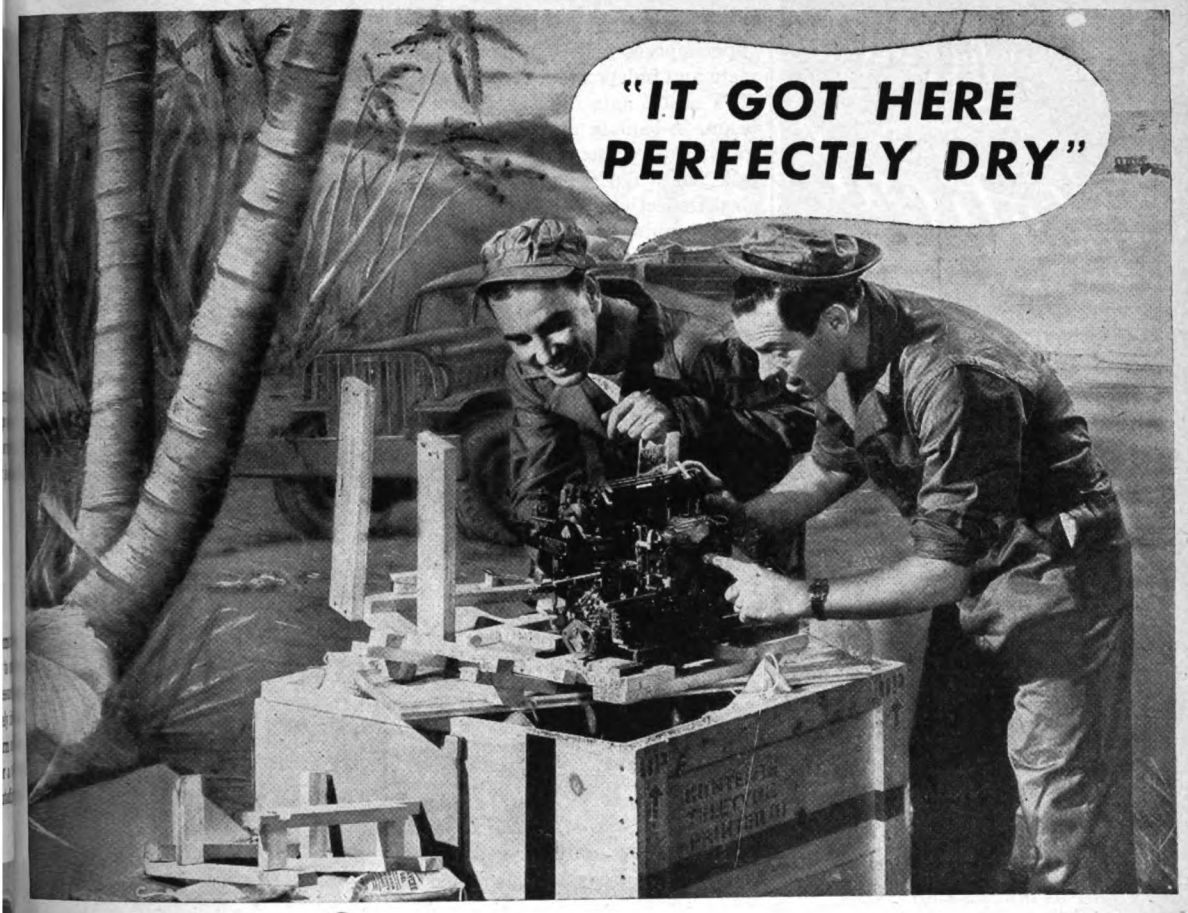

JAY CEE

SILICA GEL

PROTECTS TELETYPE* EQUIPMENT FROM MOISTURE DAMAGE • • •

Yes . . . this Teletype printer arrived "perfectly dry" . . . thanks to Jay Cee Silica Gel —which is protecting innumerable over-seas shipments of delicate machines, instruments and weapons from moisture damage.

A few small cotton bags containing this ideal drying agent are enclosed in the box or carton with the equipment. The phenomenal power of Jay Cee Silica Gel to absorb the atmospheric moisture within the container prevents rust or corrosion in transit. Jay Cee Silica Gel is also used in packages of foods, fabrics, chemicals, and other products. Moreover, it has wide application in the air conditioning, refrigeration, and chemical industries. Jay Cee Silica Gel is clear white; passes a rigid section test, meets exacting Government specifications; is strictly a quality product.

JOBBERS WANTED—A few excellent Jay Cee Silica Gel sales territories are still open to jobbers. Write for details.

* Registered trade-mark

JOLIET CHEMICALS, LTD.
INDUSTRY AVENUE
JOLIET, ILLINOIS

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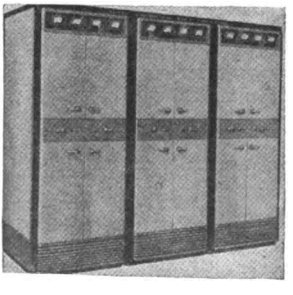
gle screen for simultaneous and superimposed traces. There is complete and independent control of the X, Y and Z axis functions for each beam. Adequate shielding between guns and plates minimizes cross talk particularly at high frequencies. Deflection plate leads, brought out through the glass envelope wall, minimize shunt-input deflection-plate capacitance and lead inductance, and also prevent interaction between signals caused by coupling between long leads. Second-anode leads are also brought out through the envelope wall in order to provide better insulation and longer leakage paths. A standard Army-Navy diheptal 12-pin base fits the standard socket. The electrode voltage ratings are similar to those of the Army-Navy preferred type 5CP1. Contact connectors for electrode leads are supplied with the tube.

F-M Broadcast Transmitters

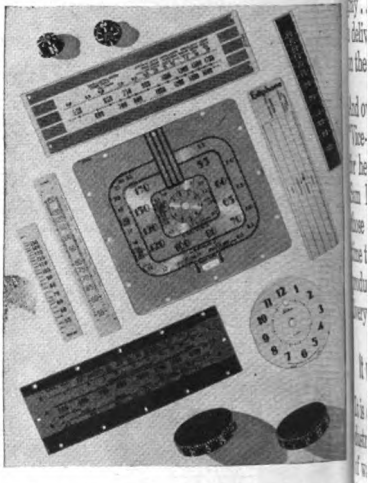
ILLUSTRATED IS an f-m broadcast transmitter, one of a line of 1, 3, 10 and 50-kw units, recently announced by Federal Telephone & Radio Corp., Newark, N. J. The transmitters are of a multi-unit design. The basic unit is the exciter which generates the initial r-f power, in itself, a complete 250-w transmitter. In this unit are included the f-m system, center frequency stabilization system, and the r-f multiplier and output stages. The 250-w output of the exciter unit is stepped up to 1, 3, 10 or 50 kw by a power amplifier unit or series of such units.



Federal's new f-m broadcast antenna arrays are fed by standard coaxial lines and consist of from 1

QUALITY PLASTIC DIALS

★ PRECISION-MADE TO YOUR EXACT SPECIFICATIONS



Where your plastic dial requirements demand precision fabrication, it will pay you to call on the experience and skill of Sillcocks-Miller specialists. They can help you in four ways:

1. In working out your own ideas.
2. In developing new ideas for you.
3. In advising you on the most practical and economical methods of fabrication.
4. In selecting the right plastics for your requirements.

Remember, it costs you less to pay a little more for Sillcocks-Miller quality.

Write for Illustrated Booklet

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A SHORT-CUT

TO HAVING THOSE CONSUMER PRODUCTS READY

This little message is addressed to the "Vice-President in Charge of New Consumer Products". For his hairs are probably turning gray . . . trying to get the factory to give him a delivery promise early enough to cash in on the expected demand.

And over his shoulder we want to talk to the "Vice-President in Charge of Production"—for he too has problems, what with Uncle Sam hounding his every waking hour on those remaining war orders—at the same time the sales department and the consumer products division are pushing him for delivery schedules.

It worked in war—it will work in peace

It is only three years ago that American industry learned a big lesson in the expediting of war production. American industry RE-discovered the principle of sub-contracting.

Instead of waiting until all departments of a plant could be tooled-up for complete production, the bottle-necks were isolated and turned over to a good sub-contractor as grist for his mill.

It worked in converting to war—it will work again in re-converting to peace time products.

Why not isolate those parts and assemblies that are likely to delay the finished job and turn them over to a good sub-contractor.

Let Lewyt Do It

Here at Lewyt, for over fifty years, we have been pinch-hitting for other manufacturers, dove-tailing our production lines with their assembly schedules. We have worked out short cuts and tricks that enable us to beat the normal time required for tooling-up.

It has worked miracles for many manufacturers . . . it may be just the answer to your problem as you face re-conversion to civilian production. At any rate it won't cost anything to investigate why some of America's leading industries have found it profitable to "let Lewyt do it".

★ ★ ★

Write on your business stationery for 48-page book, "Let Lewyt Do It"—the story of the Lewyt organization in pictures. Lewyt Corporation, 60 Broadway, Brooklyn 11, N.Y.

Lewyt

FOR MORE THAN 50 YEARS A CONTRACT MANUFACTURER . . . EXPERTLY STAFFED TO PRODUCE COMPLETE ELECTRONIC AND MECHANICAL ASSEMBLIES, COMPONENT PARTS, SUB-ASSEMBLIES AND METAL PRODUCTS, TO THE MOST EXACTING REQUIREMENTS

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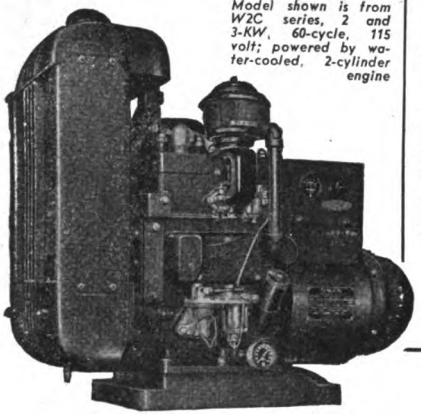
FOR ANY JOB —ANYWHERE

★ ONAN ELECTRIC GENERATING PLANTS supply reliable, economical electric service for electronics applications as well as for scores of general uses.

Driven by Onan-built, 4-cycle gasoline engines, these power units are of single-unit, compact design and sturdy construction. Suitable for mobile, stationary or emergency service.



Model shown is from W2C series, 2 and 3-KW, 60-cycle, 115 volt; powered by water-cooled, 2-cylinder engine

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Onan
POWER AND LIGHT FOR EVERY NEED

"Models range from 350 to 35,000 watts. A.C. types from 115 to 660 volts; 50, 60, 180 cycles, single or three-phase; 400, 500, and 800 cycle, single phase; also special frequencies.

D. C. types range from 6 to 4000 volts.

Dual voltage types available.

Write for engineering assistance or detailed literature".

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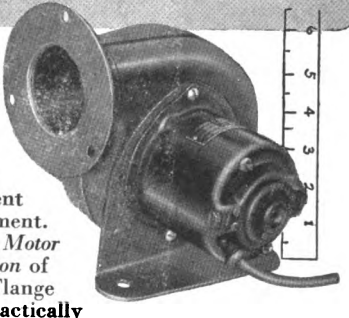

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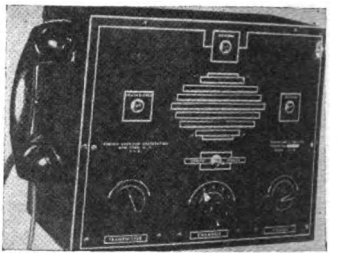
to 12 or more loops, each embodying two or more half-wave elements. The arrays are factory-tuned for easy installation.

Marine-Radio Telephones

FOUR NEW MODELS of marine-radio telephones for communications requirements in the yachting and coastal harbor services are announced by Hudson American Corp., a subsidiary of Reeves-Ely



Laboratories, Inc., 25 West 43rd St., New York 18, N. Y. The complete line covers ship-to-ship, ship-to-shore, and ship-to-Coast Guard (emergency) marine radio telephones ranging from 5 watts to 75 watts and operating on frequencies between 2100 kc and 2800 kc. Features of the units include: no variable capacitors are used in the sets; provision for the completely individual adjustment of each channel; and complete crystal control of the transmitter and receiver. An outstanding feature is the development of a new transmitter-output coupling system, designed to give greater efficiency of operation and to minimize both interference with other communications and harmonic radiation.

Potentiometer

A NEW TYPE of precision, ten-turn helical potentiometer, known as Micropot, is announced by Thomas B. Gibbs & Co., Delavan, Wis. The Micropot is linear within 1/10 of 1 percent (resistance is directly proportional to shaft rotation over the entire range of a 20,000-ohm unit to within plus or minus 20 ohms). Ten full turns on the standard ¼-in. shaft drives a sliding contact

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WHAT DO ALL THESE HAVE IN COMMON?

Radio equipment? Right. And one thing more: **a common need to make sure the transmitter is on the correct frequency.**

This means that, postwar, most transmitter users will also have in common the proud ownership of a very special piece of equipment. For there is only one piece of equipment which, at a modest price, **accurately and quickly** checks the frequency of any transmitter and is especially designed for mobile services. That is the Browning Frequency Meter.

For literature containing complete descriptive data, write for the Frequency Meter Bulletin.

BROWNING
LABORATORIES, INC.
WINCHESTER, MASSACHUSETTS

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Back Again!

NOW AVAILABLE for finer peacetime radio reception are Tru-Sonic Co-axial Speakers. Better than ever as a result of their four years of war experience, these outstanding speakers are ready to offer their superior range and tone to those who demand the best. The Tru-Sonic Co-axial Speaker is a combination of two units; a high frequency reproducer operating into an 8 cell multicellular horn, and a 15" cone low frequency reproducer. This combination speaker, complete in a single unit, gives a horizontal sound distribution of 80 degrees.

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Licensed under Western Electric Patents

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across more than 40 in. of wire-wound resistance element. The complete potentiometer measures 2⅜-in. in diameter and extends 2⅛-in. behind the panel. The running torque is rated less than 1½-in.-oz. at room temperature, and not greater than 3-in.-oz between minus 55 and plus 70 C. The resistance element (with both end terminals soldered in place) is molded as an integral part of the housing to prevent any loosening or shifting of the turns of resistance wire and to insure stability both as to linearity and total resistance. The potentiometers are available in several resistance values from 5000 to 30,000 ohms.

Aircraft Marker Receiver

MARKER RECEIVER (75 mc) provide stable lamp indicator operation under varying conditions of supply voltage, temperature and humidity. Audio frequency output at the various tone modulations is used to heat the filament of the indicator lamps, thus eliminating the need for saturable reactors, relays and other intermediate operating means. Another feature of these units is the consistent and reliable lamp and audio indications produced at low supply voltage (11 and 22-v d-c). The stabilized superheterodyne receiver with crystal oscillator utilizes i-f transformers which are provided with an easily adjustable coupling control. This coupling control simplifies adjustment procedures and permits variation in the overall selectivity characteristic to provide peak or band pass response as required. The two types of marker receivers available in-

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ude Type NM 53-A which is not nterchangeable with present equipent, and type MN 55-A which is nterchangeable with other manuacturers' receivers. Bendix Radio, Baltimore 4, Md.

Voltmeter

MODEL 565 vacuum-tube voltmeter utilizes a probe which is designed for measuring r-f voltages and which is small enough that it can be held in the hand as a test lead. The probe contains a high-frequency diode of the miniature type and it can also be used for measurement, with negligible frequency error, over a frequency range of 50 cycles to 100 mc. Shielded leads are used in the d-c voltage measurement circuits. Each shield has installed in it a 20-meg isolating re-

sistor which also acts as part of the multiplier resistors. Input impedance of 80 meg on the 1-v range and 40 meg on the 500-v range makes it possible to make voltage measurements, with negligible error, in circuits having extremely high impedance. A balanced bridge-type circuit (using nearly 100 percent degenerative feedback) eliminates errors due to line-voltage shift and due to grid current in the tube which operates the meter. D-c voltage ranges of 0-1, 0-2.5, 0-10, 1-100, 0-250, and 0-500 and a-c voltage ranges of 0-1, 0-2.5, 1-10, 1-100 and 0-250 are provided by pushbutton selection. Supreme Instruments Corp., Greenwood, Miss.

Television Connector

ILLUSTRATED IS A television connector designed to utilize a minimum of space behind the prongs of the tube. The connector can be used

WORLD'S FASTEST PLANE *uses* ANDREW COAXIAL CABLES!

Lockheed's sensational new jet-propelled super fighter, the P-80 "Shooting Star," is the world's fastest and highest flying plane.

It is highly significant that Andrew coaxial cables were chosen for the vital radio and radar equipment installed in the P-80. They were selected because they are much more resistant than ordinary solid dielectric cables to the high temperature encountered in the tail of the plane.

Andrew Co. is a pioneer manufacturer of antenna tuning and phasing equipment, including a complete line of ceramic insulated coaxial cables and all necessary accessories. *Write for catalog.*

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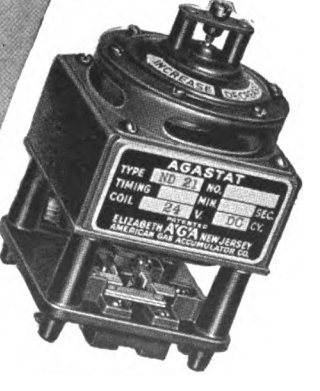

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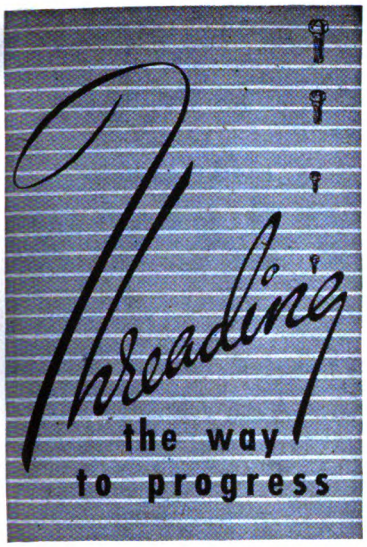

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in television sets, oscilloscopes and other similar applications. It is designed for the higher voltages and provides longer leakage paths between the contacts protecting the skirt around the prongs of the tube to preclude the possibility of shock. Alden Products Co., 117 N. Main St., Brockton 64, Mass.

Two-Pole Circuit Breaker

A SMALLER, lighter, more compact, two-pole breaker with a more efficient blow-out action and a faster latch mechanism has been added to the line of circuit breakers made by the Heinemann Circuit Breaker Company of 97 Plum Street, Trenton, N. J.

The unit illustrated here, is fully electro-magnetic, is designed for service on 230-v a-c or 250-v d-c of 50 amp maximum. It may be connected either front or rear. It will carry full load continuously and

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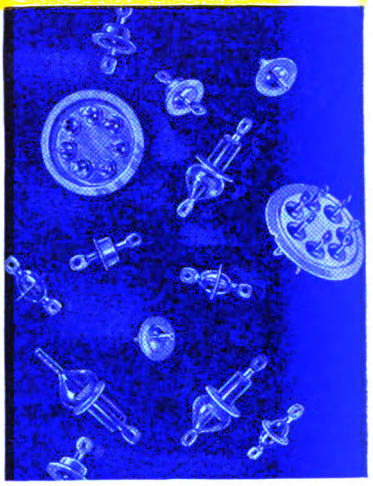

Buyers who have waited through the war years will be looking for big improvements in your products. You'll have to meet civilians' expectations . . . just as you have met military specifications.

You can do it by building longer life, better performance, more trouble-free operation into your products. That calls for Sperti Hermetic Seals, the rugged, dependable, war-proved seals that effectively shut out dust, moisture and deteriorating agents.

Sperti Hermetic Seals are durable, one-piece units, easily soldered-in at less expense. Because of Sperti's advanced manufacturing methods, plus exhaustive tests and inspections, you'll get "true" seals that cut down production delays and costly rejects in the inspection line.

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- Seal out dust, fungus, salt spray, sand atmosphere at high altitudes, etc.
- Will add longer life to a product.
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- Are one-piece, rugged units. Easily soldered-in at less expense.

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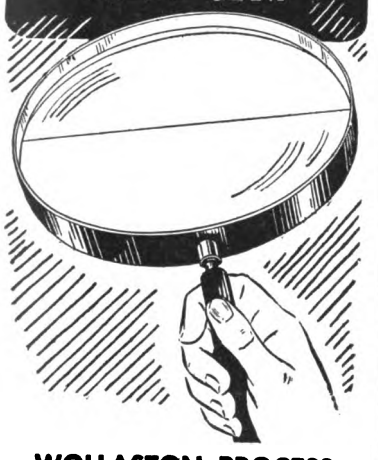
WIRE SO FINE IT MUST BE *Magnified* TO BE SEEN



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This organization specializes in wire and ribbon of smaller than commercial sizes and closer than commercial tolerances. ***Write for List of Products.***

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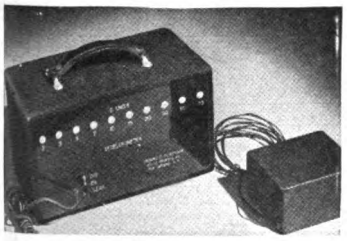
has instantaneous trip at eight to ten times full load. It also has a selection of three time delays, any one of which may be specified. Overall dimensions are: 5¼ in. long by 2-1⁄16 in. high and 2 in. wide.

Meter for Measuring Maximum Shock

A MEASURING DEVICE, designated as the G Meter, reads the value of the maximum intensity of shock, even though that maximum exists for an extremely short duration. The gravitational unit G is used as the unit of measure. The meter consists of the G meter itself (which is subjected to the shock) and the electronically-operated indicating mechanism. The two are interconnected by a multi-wire cable. The entire device operates from a-c power. Readings are obtained by means of a series of lights which glow at a given impact and which represent graduating degrees of shock.

The meter can be used to determine the shock involved due to



vibration even at relatively high frequencies; shock transmitted to the various components of any moving mechanism; shock administered to a radio, or a carburetor, or any other part of a car or a plane.

Another application of the meter is in packaging materials to determine various means for providing full protection of packaged material. In this application, the meter is securely mounted and incorporated in a mock-up of the article whose packaging is to be tested. The size and weight are adjusted to simulate the article itself. This mock-up is then wrapped, and the completed package dropped a known distance. The reading obtained is a direct indication of

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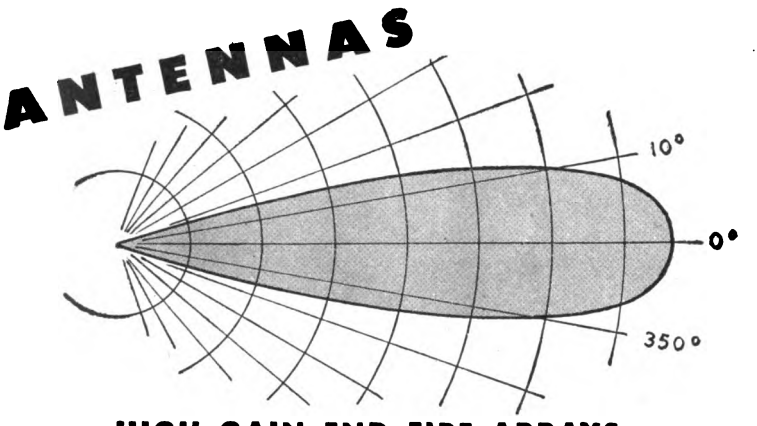

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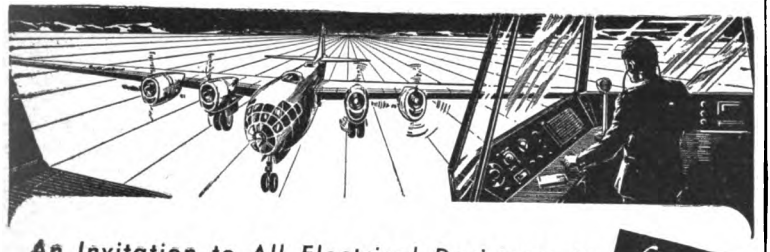

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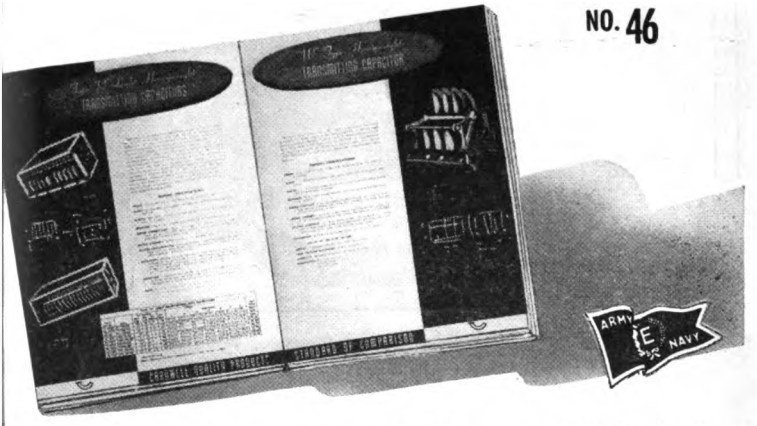

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tion engineers and is designed to provide an understanding of the principles of electronics and to give an idea of the part electronics will play in future industrial developments. A brief discussion on the fundamentals of conversion and control of electric power in a load prefaces the introduction to the subject of electron tubes. The discussion of tubes is divided into two main parts: vacuum and gaseous. Differences between a vacuum tube and the equivalent mechanical device, methods of specifying tube performance, application of tube characteristics for design purposes, and use of the high-speed response of the tube are explained. Principles of tube detector action with applications, and principles of tube oscillators with application to induction and dielectric heating are also given. Line drawings, curves, and sketches add to the comprehensiveness of this booklet. Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

RCA Questions and Answers. A 48-page book entitled "RCA, What It Is, What It Does" was published in response to questions that are often asked of RCA. The booklet covers such subjects as broadcasting, television, manufacturing, communications, marine radio, technical training, research and engineering and other data about RCA. Radio Corporation of America, 30 Rockefeller Plaza, New York 20, N. Y.

Substitute Tubes for Diathermy. A substitution list of tubes for diathermy apparatus has been published by Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago, Ill. The leaflet lists the equipment by manufacturer and shows which type tubes are furnished with the unit and the Taylor tube substitute.

Bushings and Insulators. Dimensional and electrical data on Tronex 1300 line of solder-seal bushings is contained in an 8-page booklet available from T. C. Wheaton Co., Industrial Div., Millville, N. J. One page of the booklet illustrates types of electronic components available, and two pages of the booklet give background data on Wheaton.

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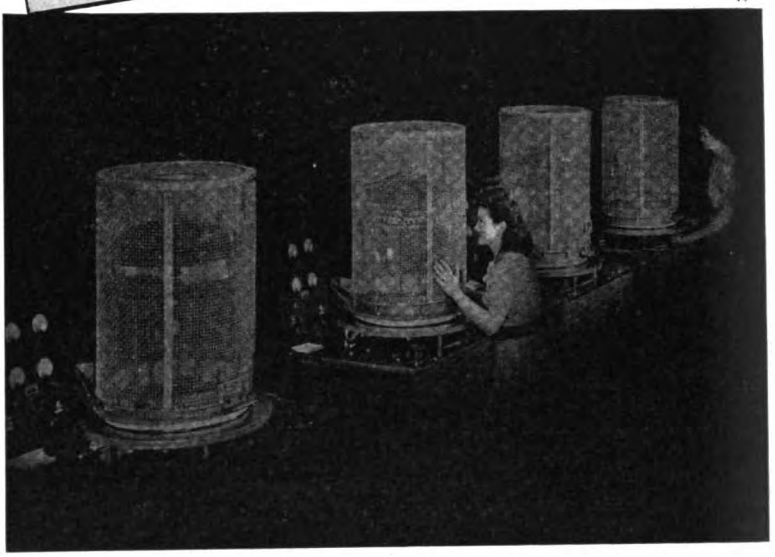

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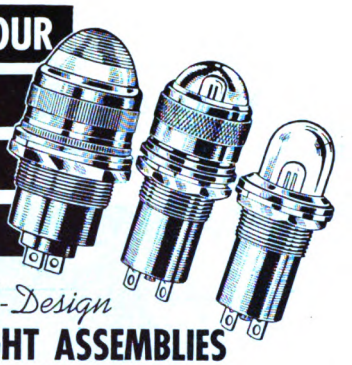

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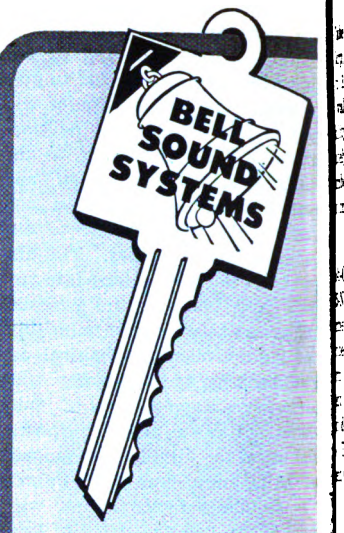

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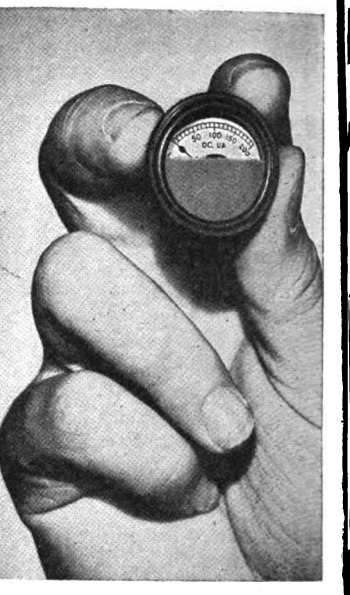
Railroad Communication. A brochure which tells the reader that this company has engineered a comprehensive and integrated communication system which can be adapted to the individual requirements of each railroad. The brochure contains many illustrations relating to different phases of railroad communication. Maguire Industries, Inc., Electronics Div., 1437 Railroad Ave., Bridgeport, Conn.

Electronic Equipment. Rectifiers, test equipment, aerial printer, electronic timers, solenoid brakes, 400-cycle timers, junction boxes, oscillators, switches, solenoids, antennas are all illustrated in a 4-page bulletin entitled "Electronic Equipment" which tells the reader that Richardson-Allen Corporation specializes in electronic engineering, development and production. 15 West 20th St., New York 11, N. Y.

Radio Accessories. General Cement Manufacturing Co., of Rockford, Ill., have issued a catalog (No. 146) which contains a complete listing of their line of radio cements, chemicals, hardware, cabinet repair kits, repair parts, tools and other service accessories.

Electrical Instruments. Types TD and TA, RD and RA, DD and DA, OD and OA, VD special, PD and PA, and VD and VA improved ammeters and voltmeters are illustrated and described in three separate pieces of literature available from the manufacturer, The Norton Electrical Instrument Co., Manchester, Conn.

Precision Instrument Dials. A 4-page bulletin (Form No. 1-745-2M) from American Dial Co., Inc., (450 West 45th St., New York 19, N. Y.) contains many illustrations and descriptive data of precision instrument dials which have been produced by means of an optically-recording instrument which utilizes a combination of optical and electro-mechanical principles. Dial graduations are available in any dimension from three microns (0.000120 in.) in width for microscopic dials up to any desired size to meet



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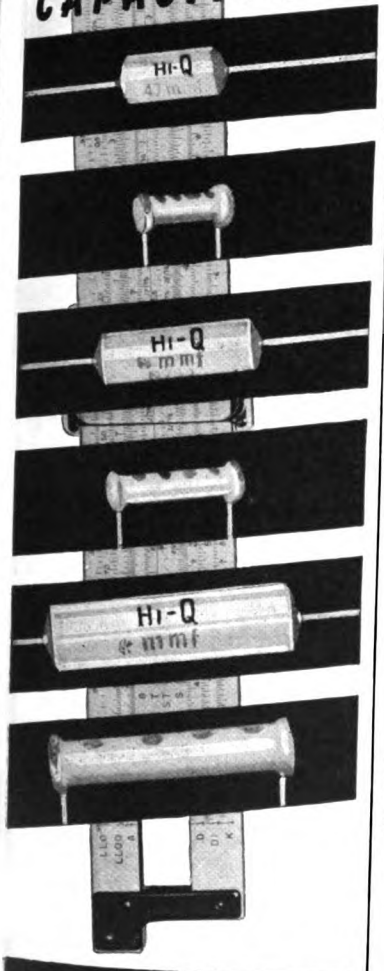

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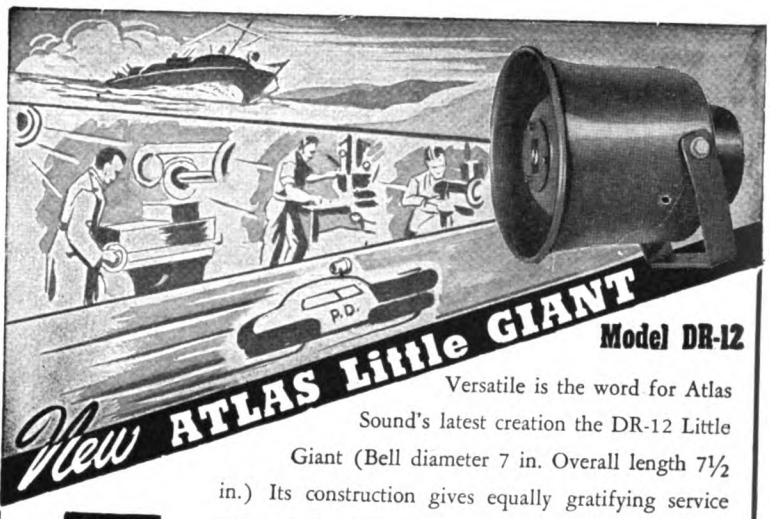

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Industrial Tube Manual. A new 412-page technical manual on electronic tubes, prepared by General Electric Company's Tube Division, is available from GE at a cost of $2.00. The manual is intended to serve as a guide in selecting tubes for industrial applications. Popular applications of ignitrons, phototubes, thyratrons, phanotrons and other tube types are given in the manual, which is illustrated with photographs, outline drawings and performance curves. The manual has an expander-type binder and provision has been made by GE to supply purchasers with new data as prepared for the manual from time to time for a nominal annual charge of $1.00. Electronics Dept., 267-122 at Schenectady, N. Y.

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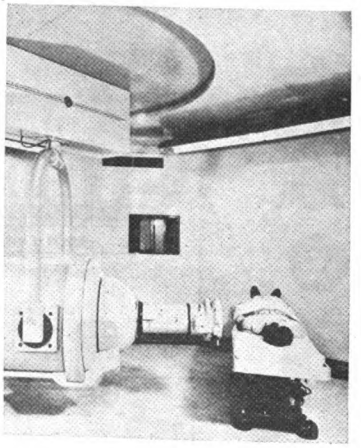

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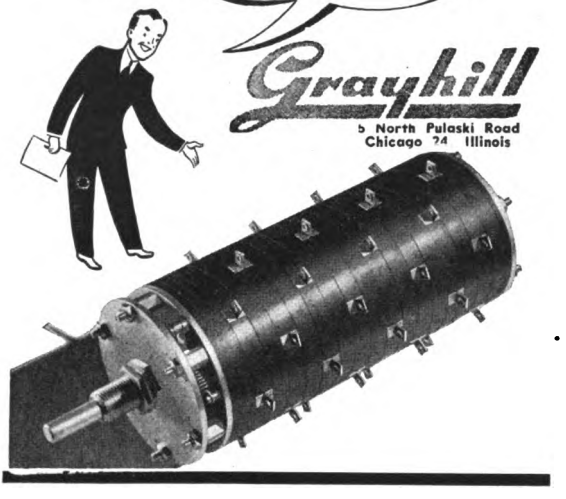

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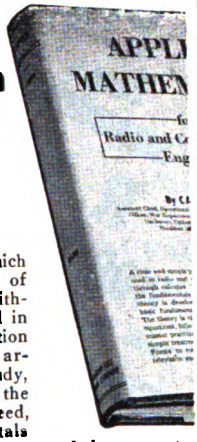

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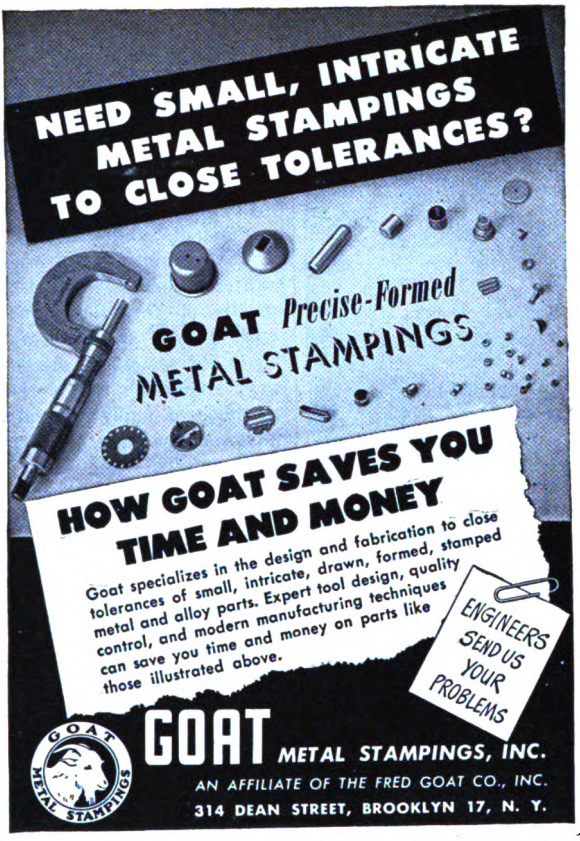

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upon many variables. In this book, the author has isolated the factors and analyzes each one individually. He assumes that the reader is an electrical engineer with a broad and detailed knowledge of the equipment and apparatus used to generate and distribute electrical power.

To comprehend and interpret the subject matter, which consists mostly of formulas complemented with a brief concise statement of their derivation, an electrical engineer should be well versed in the methods of analytical calculus and have some acquaintance with higher mathematical functions.

The formulas presented have many practical applications, but few of the specific applications are discussed in detail. The formulas cover the calculations necessary for evaluating reactance, eddy current loss, skin effect, inductance, and magnetic field strength of coils and conductors that carry electrical current.

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Chapters dealing with trans-

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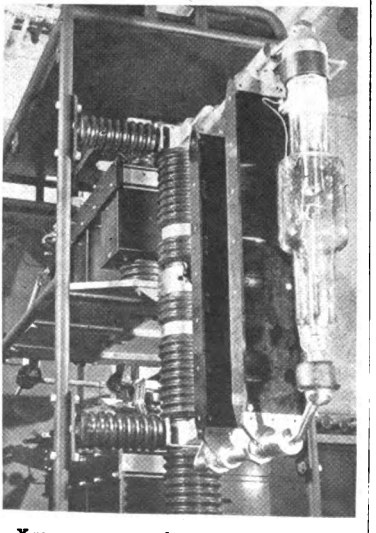
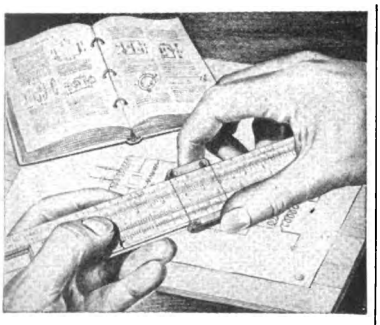


X-ray exposures short enough to catch the action of a bullet traveling down a gun barrel are produced by this Westinghouse tube. The 600 million watts for the exposures are delivered from six capacitors of the surge generator behind the tube



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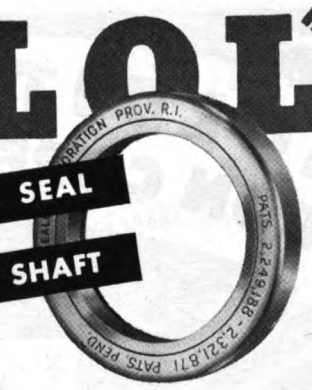

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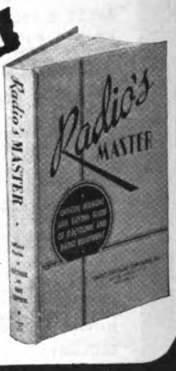

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former design problems include formulas for determining reactance in concentric core-type transformers and those having interleaved components, cross-section of cores, and operation of delta and V banks. Other chapters deal with the reactance of overhead stranded conductors at wide spacing, round tubes, square tubular busbars, and rectangular or strap conductors such as are used to carry heavy alternating currents in busbars on switchboards and in the supply circuits of electric furnaces. Formulas are presented for the calculation of eddy-current loss in transformer windings, armature coils, and in round wire.

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Numerous footnotes throughout the text refer the reader to engineering society papers and technical articles that deal with the subject under discussion.—J.K.

• • •

Applied Mathematics for Radio and Communication Engineers

By CARL E. SMITH, *President (on leave to the War Department), Smith Practical Radio Institute. McGraw-Hill Book Co., Inc., New York, 231 pages, $3.50.*

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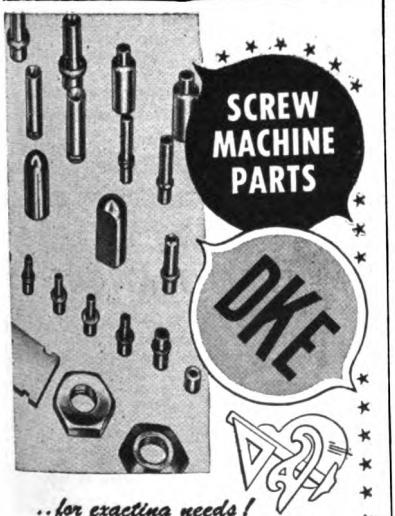

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and advanced algebra, and concludes with chapters on differential and integral calculus. The concisely presented material is readily grasped by those reading the book as a review. However, to the readers covering the material for the first time, essential points are not brought out with sufficient force to be readily appreciated. (It is intended that the book be used in connection with a correspondence school.) Answers to the many problems are included.

Illustrative mathematical solutions are well explained. The book has a good index—indexing makes or breaks technical books. Although the contents is solely mathematical, the author makes it clear to readers why particular mathematical knowledge is presented, and why it will be useful to readers. For example: In introducing Chapter 11 on hyperbolic trigonometry the author observes that "Since traveling waves on a transmission line are very conveniently expressed in terms of hyperbolic functions, this chapter will be devoted to the mathematics of these functions."

On pages 87-89 there is developed a slide rule solution for right triangles, unfamiliar to this reviewer,

• • •

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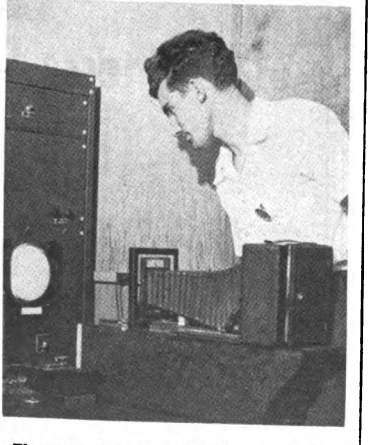

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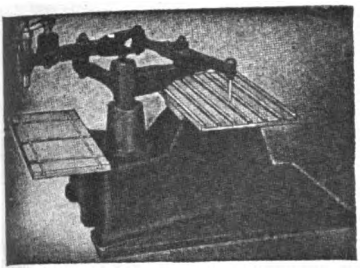

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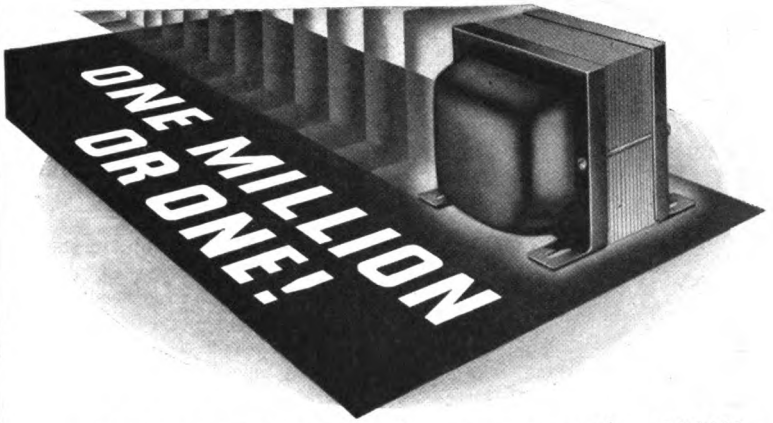

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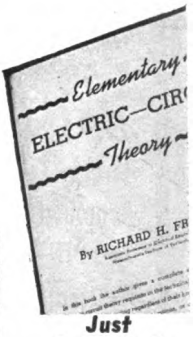

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The symbol used for factorial in this book is not the preferred ! but ⌊, which can be mistaken for the angle sign and on page 176 in Eq. (9) has been printed as an angle sign ∠.

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The author makes the initial transition from the low frequencies to the ultrahighs by explaining the use of Lecher wire systems and concentric cables as tuning circuits, then describing the first attempts by Barkhausen and Kurz to put transit time to work in tubes. This introduction paves the way for chapters on the magnetrons and klystrons, followed by a chapter on use of transmission lines as inductances, capacitances, tuned circuits, and matching stubs.

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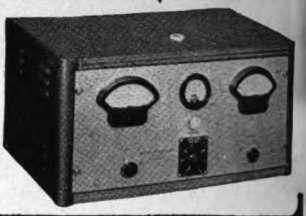

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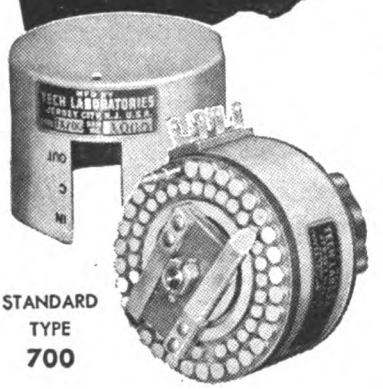

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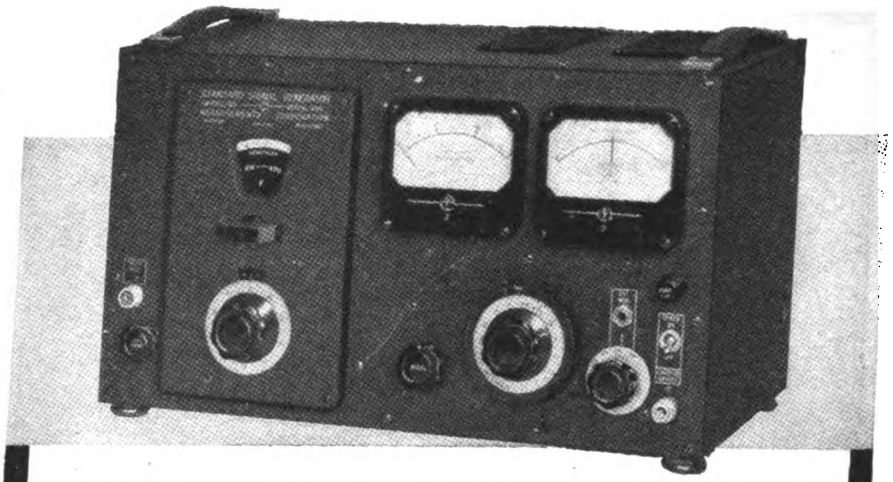

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Elementary Electric- Circuit Theory

By RICHARD H. FRAZIER, J
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N. Y., 1945, 414 *pages*, $4.

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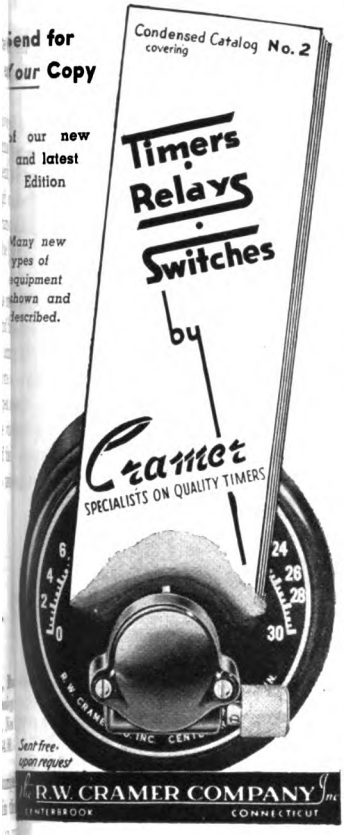

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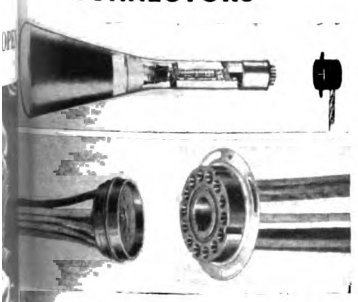

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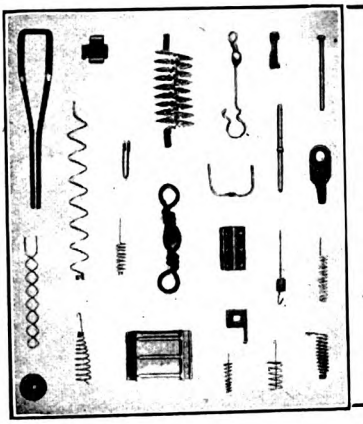

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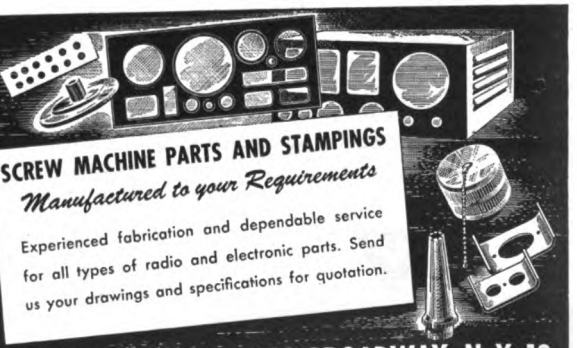

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the power engineer and the communications engineer tend to confine themselves too narrowly to their respective divisions of the field, with the result that interrelated problems may not be adequately handled by either."

The work is self-contained. It begins with definitions and concepts of electric circuits, takes up methods of circuit analysis using resistive networks as examples, introduces a-c concepts and the corresponding complex algebra for handling them, discusses nonsinusoidal waves and polyphase networks, and concludes with transients.

The book is intended as a text for electrical engineers who have completed fundamental physics and mathematics courses. Rather than separating the class into power and communication majors when they begin studying circuits, the instructor can hold it together by the approach of this text. For example, in discussing nonsinusoidal waves, waves encountered both in power and in communication circuits are used as illustrations and problems for Fourier series and graphical analysis.

The author has interspersed the text with non-technical observations which aid in orienting student engineers to their technical studies. As an illustration, on page 2 the author observes that "The engineer should be skilled in leading a double life—one in the concrete world of physical apparatus and one in the abstract world of ideas—and in interpreting each realm in terms of the other."

Brief introductory paragraphs which orient readers at the beginning of each chapter are useful. The quantity of condensed technical information in this book cannot be presented without giving, beforehand, an indication of where the student is being led. Until he sees his goal, he cannot follow. In short, it is a technical book written by a pedagogue, which is unusual!

More books of this sort will be written. It coordinates. The wealth of information and technique that engineers must acquire today cannot be learned without such books. It is indicative of the contemporary trend away from limited specialization, toward broad coordination. —F.R.

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Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published.

Hartley Law

DEAR MR. HENNEY:

YOUR COMMENTS in "Cross Talk" in the June issue of ELECTRONICS concerning the band width of frequency necessary for the transmission of intelligence are very timely.

I have reason to believe this concept was well known previously to its formulation by Dr. Hartley in 1927.

I recall hearing a presentation by Dr. Alexanderson of General Electric on the results of his high-frequency alternator at the summer convention of AIEE in Swampscott, Mass. This must have been in 1921 or 1922. In the course of his remarks, Dr. Alexanderson noted that the transmission band width of the transmitter and receiver required to be increased in exact proportion to the increase in keying frequency, and furthermore stated that this requirement necessarily proportionately reduced the total number of available channels in any given portion of the spectrum.

His explanation was so clear that I still remember it vividly, although I was only 14 or 15 years old at the time. Anything which can be explained satisfactorily to a youngster is undoubtedly pretty well understood by the teacher. Therefore, I would like to nominate Dr. Alexanderson as the proponent of the law of the relationship of information, time, and band width.

LOVETT GARCEAU
Director, Electro-Medical Laboratory, Inc.
Holliston, Mass.

Research indicates that a joint meeting of AIEE and IRE was held in New York City in October 1919 at which Dr. Alexanderson had a paper, Transoceanic Radio Communication, which discussed one application of the Hartley Law. In this paper Dr. Alexanderson pointed out that the higher the speed of sending, the greater must be the separation required between

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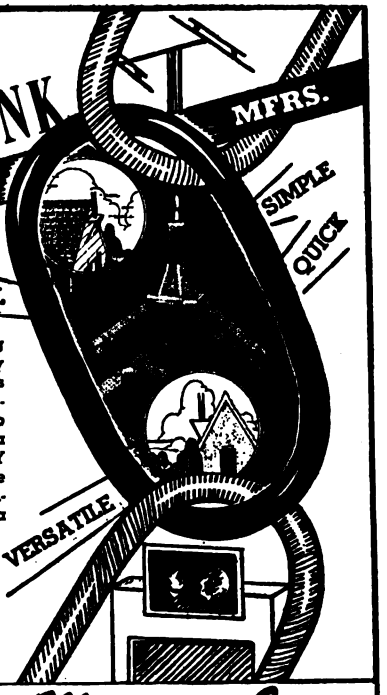

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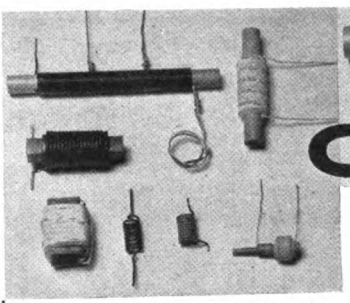

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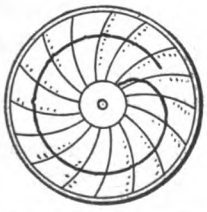

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adjacent channels. In 1923 at Swampscott, Dr. Alexanderson, A. E. Reoch and C. H. Taylor delivered a paper before AIEE, The Electrical Plant of Transocean Radio Telegraph, but there is nothing in the formal report of this paper which indicated that the relations between the amount of intelligence to be transmitted and the time or band width were discussed. It is quite possible that this is the convention which Mr. Garceau remembers and that the informal discussion related to the matter at hand.

There is no doubt that numerous pioneers knew and appreciated at a relatively early date, the relationships we have been discussing. As a matter of fact, Mr. Hartley himself knew of the manner in which the factors are tied together. Paul Findley of the Bell Telephone Laboratories has found in the Laboratory files a 14-page memo dated December 9, 1918 in which Mr. Hartley formulates the general relationship he published more formally eight years later.

Perhaps the matter is like the law of gravitation—the effects of which were generally understood for a very great time but which remained rather vague until Newton

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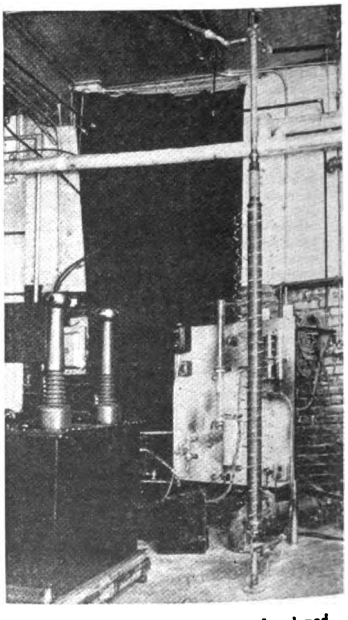

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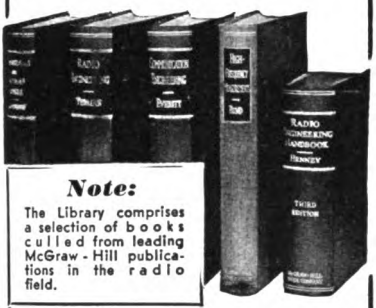

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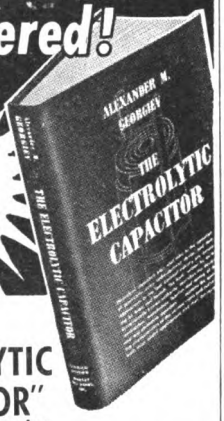

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Dear Mr. Henney:

THE PROPOSED Hartley Law, as stated in the "Cross Talk" section of ELECTRONICS for June, 1945, undoubtedly applies to a system wherein scanning methods are employed but does not necessarily apply to a system where the intelligence contained in a large number of elements (such as the individual elementary areas in a video image) are transmitted simultaneously. In the latter system, the band width is entirely dependent on the allowable "crowding" of frequencies consistent with satisfactory frequency differentiation at the receiver.

For example, if frequency is made the "tag" for positioning elementary areas in a video image, and assuming, for the sake of argument, that it is possible by special means to assign frequencies differing from each other by only one-quarter cycle, it then becomes possible to transmit 240,000 elementary areas simultaneously in a band width of only 60 kc.

It is beyond the scope of this letter to discuss whether or not this is possible, but I think you will agree that if such is possible, the so-called Hartley Law does not apply to this system. It is impossible to reduce the band width considerations of the system just described to a law, because they are obviously based on experimental factors, such as the frequency discrimination possible in practical forms in crystal filters. Therefore, for the sake of accuracy, it might be advisable to call attention to this limitation.

PALMER H. CRAIG
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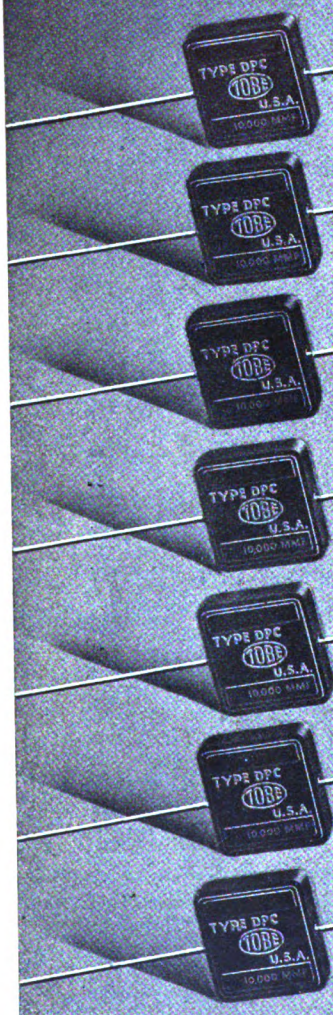

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CROSS TALK

▶TALK . . . In the October issue of *The American Magazine*, Paul A. Porter, Chairman of the FCC, has an article entitled "Radio Must Grow Up." In it Mr. Porter comments on the growing displeasure of the listening public about the increasing blatancy and poor taste of commercial announcements.

Because of Mr. Porter's position, his interest in and awareness of this attitude on the part of the public is most encouraging. And because he mentions an incident occurring in the mountains of New Hampshire, a locality with which we are familiar, a report on the radio situation there may not be amiss.

In Mr. Porter's incident a famous scientist and his friends listened to an afternoon symphony with great enjoyment only to have the music suddenly followed by a "squalling, dissonant, nasty singing commercial." The scientist promptly threw out of the house the products advertised by the commercial and vowed that no more of the stuff would be permitted to enter. Scientists, of course, are few and are probably not representative of the people. On the other hand, the people are not dumb. Once you get away from the cities, people become folks and you can get close to them. You can find out, for example, how they feel about things. In the mountains of New Hampshire people listen to the radio but shut their ears to the plugs. When asked what they think of the commercials, they invariably say, "Aren't they awful!"

So far as radio service is concerned, this part of New England is poorly served. Field strengths are not great enough to override static and man-made noise. At dusk the best of the daytime stations are badly garbled and soon disappear in a rush of distant stations, few of which deliver good service because of fading and general interference. WQXR, the old standby for New York people who believe that radio means music, comes in well at first but birdies and whistles finally get it down. At 8:55 WABC comes in long enough to bring in comment-free news, thanks to Quink and Johns Manville. As a matter of fact WABC is the best CBS station heard. The radio problem is solved, however, by the Yankee Network f-m station on top of Mt. Washington. Its signals are clear and steady, free from noise and fading. It, however, carries Mutual programs, and since Mutual seems to have gone whole hog for talk programs there isn't much from Mt. Washington for New England people who believe that radio means music.

New Englanders are no better and no worse off than the rest of the country when it comes right down to programs. There simply is too much talk, not alone advertising talk but all kinds of talk—program talk, news comment talk, program notes talk, drama talk. People here really want music and music is one of the things that the broadcasters seem to be eliminating from their programs. They even hire a good musician like Oscar Levant and make him crack jokes!

It is just a hunch, but if the broadcasters did not dilute their programs with so much other corny chatter the bad taste of the advertising blah would be evident even to the men who prepare it.

▶PAPER . . . With the removal of the restrictions on paper, ELECTRONICS' first move was to add to its circulation list the names of more than 5000 engineers who have been patiently waiting, some for many months, to get their first copies. The next step was to improve the paper stock from 31-pound to 40-pound paper; in January the page size will return to its old dimensions of $8\frac{3}{4} \times 11\frac{5}{8}$ inches; and in the early months of 1946 the paper will be improved again to 45 or 50-pound full coated stock.

Not content with these improvements, the editors have determined to bring to the readers a rapid and full report of wartime developments hitherto restricted. This issue, for example, contains a considerable amount of material which was unmentionable a bare month ago.

And by the way, there are more editorial pages in this issue than have ever appeared between the covers of ELECTRONICS. As the months go by the readers will have ample evidence that so far as this magazine is concerned, the war is indeed over.

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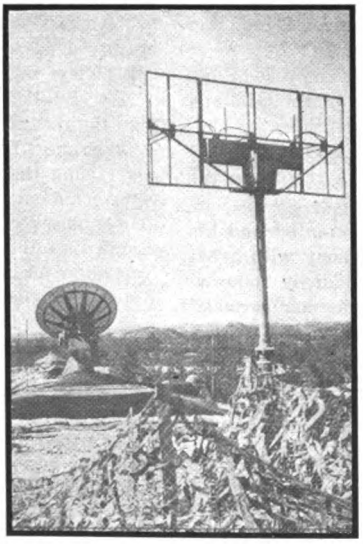
Report on WARTIME ELECTRONIC DEVELOPMENTS

On the following pages, and continuing in succeeding months, ELECTRONICS presents a series of articles describing electronic systems, equipment and components developed during the war, information on which the future course of the industry largely depends

IN THE FOLLOWING PAGES, and in issues to follow, ELECTRONICS undertakes its share of a huge project: to acquaint industry with the accomplishments of the war period in its field.

For more than four years technical workers, backed by almost unlimited resources, have researched, designed, developed, and produced all manner of electronic gear behind closed doors. Information on this vast effort has been interchanged only where the value of exchanging ideas clearly outweighed the threat to military security, and then only between groups working in similar equipment. The radar specialists knew little if anything of the plans to use television in military operations despite the close relationship between the two arts. Even more remote was the group developing the variable time (VT) fuze, a c-w radar carried in a bomb or howitzer shell. Off in still another corner were the "straight-communication" boys who did wonders to supply what the Army and Navy needed above all, reliable radio contact between combat units and commands. And among the most hush-hush were the "rcm" (radar and radio countermeasures) workers whose business it was to fox and outfox the enemy in his use of radio and radar.



SCR-584 radar and RC-184 identification equipment of Battery B, 5th Antiaircraft Battalion. The radar (left, dug in) is the 10-cm 300 kw job which licked the buzz-bombs. RC-184 (antenna, right) transmits pulses on a lower frequency to friendly aircraft which retransmit a coded reply. By this means the buzz bombs were separated from Allied fighters chasing them, and in the end, 80 percent of the V-1's were shot down by radar control

So it is that many technical workers have been in possession of a small part of a particular field, but barred by security or lack of time from other parts of the electronic art. Material available for publication has been scanty (but not entirely so as the accompanying bibliography shows) and of theoretical nature, especially on the topics of greatest technical interest. Even now many restrictions apply, but present indications are that soon all wraps will be removed from most systems, equipment and components developed for use in the war.

That a good start has already been made will be evident from the following 26 pages, all of which were assembled within six weeks of the end of hostilities. The articles cover a wide range. Radar assumes a central position, as indeed it must in view of the prodigious effort expended on it. But interest is by no means confined to radar. The paper on the AN/PRS-1 mine detector describes a remarkable device which saved untold lives, albeit by a technical principle which is even now very imperfectly understood. The Loran navigation system, one of the great American contributions, is well known in fact if not in name to listeners who have tuned through the 160-meter ham band since 1942. The ground-controlled approach system for bringing aircraft safely down through fog has a bright future. The VT fuze, whose vacuum tubes can stand the shock of being thrown from a gun with an acceleration of 20,000

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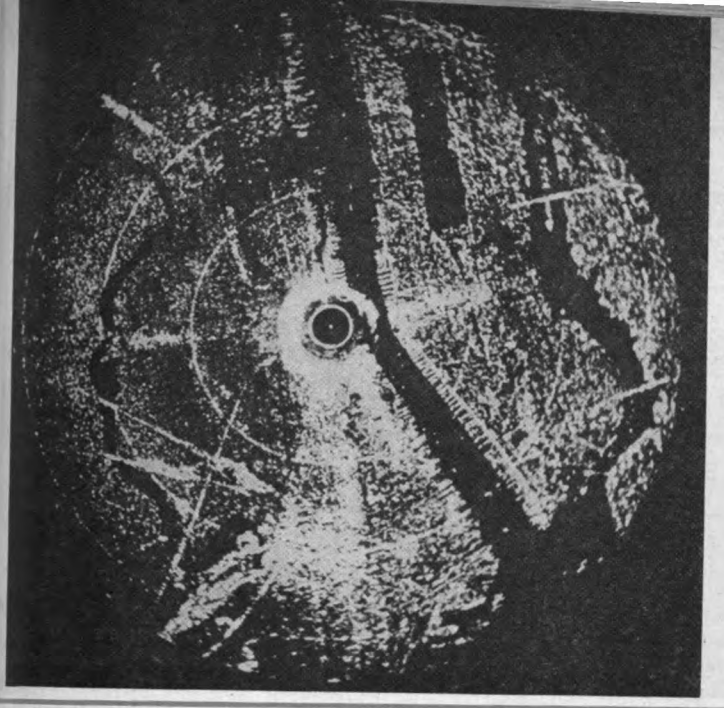

The radar equipment which produced this PPI picture of Manhattan Island and nearby New Jersey (looking north) was still under development at the war's end. The resolution of the individual docks along the Hudson River, bridges, islands, ships, and even railroad tracks (diagonal lines lower left) is made possible by the use of a wavelength shorter than 3 cm

times gravity, is pure Jules Verne.

For those who like their radar concentrated, the table under "Radar Specifications" is prescribed. Somewhat more dilute, and perhaps more generally informative, is the description of the SCR-584, the most versatile radar to be designed by any of the warring powers and the first S-band radar (10-cm wavelength) to be described. The GCA system also employs radar. All these will be found in this issue.

This is merely a start. It would be imprudent in a competitive world to list detailed plans for future issues. But assurances of early declassification of equipment by Air Force and Navy, following the noteworthy step already taken by the Signal Corps, leave no doubt as the general trend: airborne and shipborne radars to match the ground radars here tabulated; shf communication by pulses and otherwise; television systems reduced to the airborne, and even the bombborne, stage; tubes for creating more power at higher frequencies than, perhaps, anyone can use for a non-military purpose; test equipment covering every phase of uhf and shf technology; simple control circuits for pilotless aircraft.

In short, after the famine, the feast. It is the plan of the editors to continue the ELECTRONICS War Report for as many months as their readers find it interesting. Material is available, from among the radar and radio equipment already declassified, to fill extra columns for many months. The editorial task is one of selecting the more important contributions and presenting them lucidly. Suggestions from readers concerning suitable material will be gratefully received and carefully considered.

ARTICLES ALREADY PUBLISHED

by electronics

RADAR WARFARE.....October 1945, p 92
Technical and tactical factors behind the uses of the electronic device

CONTROL FOR FORMATION FLYING.....October 1945, p 98
Accessory for C-1 autopilot permits effortless maneuvering

TECHNICAL BASIS OF ATOMIC EXPLOSIVES.....October 1945, p 109
Production and use of uranium-235 and plutonium

WIRE SPLICE DETECTOR.....September 1945, p 98
Detects discontinuities in field wire laid from C-47 transport at 125 mph

THE SCR-268 RADAR.....September 1945, p 100
Unit designed to direct anti-aircraft searchlights and guns

MOTOR NOISE UNIT FOR TRAINER.....August 1945, p 96
Noise resembling that of airplane motor is produced electronically

THE RADAR EQUATION.....April 1945, p 92
Power and sensitivity are related to distance and size of detected object

THE K-8 COMPUTING GUNSIGHT.....January 1945, p 94
New servo automatically provides correct deflection to insure hits

AUTOMATIC MAP TRACER.....November 1944, p 94
Army's land equivalent of blind-flying apparatus

ARMY RADIO D-F NETWORKS.....November 1944, p 118
Signals from lost aircraft are utilized to establish position

ELECTRONIC AUTOPILOT CIRCUITS.....October 1944, p 110
Amplifier unit energizes servo motors in response to gyro-produced signals

ARMY AIRWAYS COMMUNICATIONS SYSTEM.....August 1944, p 98
Army Air Force affiliate points the way for post-war air travel

NEW ENEMY RADIO EQUIPMENT.....July 1944, p 132
Analysis of German and Japanese sets manufactured in 1943

FUNGUS-PROOFING PROCEDURE.....June 1944, p 92
Discussion of fungicides used in tropicalization of military equipment

TURBO REGULATOR FOR AIRPLANES.....May 1944, p 108
Provides constant power condition for each engine at any altitude

JAP RADIO EQUIPMENT.....May 1944, p 126
Detailed description of the Model 13 high-frequency command set

GERMAN VHF COMMAND SET.....April 1944, p 132
Detailed description of the FUG-16, operating in the 38-42 mc band

CAPTURED AXIS EQUIPMENT.....March 1944, p 94
German FUG-10, used in bomber and reconnaissance aircraft

SUPPRESSING JEEP RADIO NOISE.....December 1943, p 96
Body bonding, filtering and tests

ELECTRONIC MEGAPHONES.....November 1943, p 125
Vacuum-tube amplifiers aid Navy vessels on convoy duty

RADAR DEVELOPMENT.....June 1943, p 274
Official U. S. and British releases covering the early work

ELECTRONICS IN THE NAVY.....April 1943, p 72
Naval uses, plus outline of organization under Bureau of Ships

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THE LORAN SYSTEM . . Part I

Pulsed transmissions on 1700-2000 kc provide precise over-water navigation for ships and aircraft at distances up to 1500 miles from shore-based stations at night, or 750 miles by day. Operating principles of the most important long-range navigation system to come out of the War

LORAN (from Long Range Navigation) is a system of radio navigation which permits the navigator of a ship or an aircraft to determine his position with an accuracy not worse than 15 miles at a distance of 1500 miles from shore. It is one of a family of systems, known as "hyperbolic navigation systems", which measure the relative time of arrival of two or more radio signals sent synchronously from known points.

Loran operates in the region from 1700 to 2000 kc, and employs high-power pulses of approximately 50 microseconds duration.

History of the Development

The Loran development is based on a proposal of Dr. Alfred L. Loomis, of the National Defense Research Committee, who in 1940 devised a hyperbolic method of position finding and suggested that the Radiation Laboratory, then being formed at M.I.T., undertake to develop the system. Prior to this, Robert J. Dippy of the Telecommunications Research Establishment in England had devised independently substantially the same system, which was christened the "Gee" system and developed to the point of operational use in 1942. In that year an exchange of information between Radiation Laboratory and T.R.E. revealed that the two groups were working on the same system, but with different aims.

The Gee system was intended for the guidance of high-flying bomber aircraft over Germany, at maximum distances of 200 to 300 miles, and employed line-of-sight frequencies in the region from 40 to 80 mc. The Radiation Lab group was working on a system, later christened Loran, which would serve equally well for aircraft at high altitudes or naval ships on the surface and which would have a range greater than 500 miles, for the defense of American shores. The frequency adopted for Loran in the winter of 1941-42 was 1950 kc, just inside the then recently vacated 160-meter amateur band. After the interchange of information, the two projects were coordinated and thereafter the two systems, Gee for short ranges at high altitudes and Loran for long ranges at any altitude, were exploited independently by the two groups.

In 1942, the first Loran stations were put in operation along the Atlantic coast from Delaware to Greenland by the Radiation Laboratory and later turned over, for routine operation, to the Coast Guard. In that same year shipborne navigating equipment was manufactured in small quantity and later appeared in several improved models in sufficient quantity to equip the entire fleet. By 1943 production was in full swing on the AN/APN-4 airborne navigating (receiver-indicator) equipment, and in 1944 a new version, the AN/APN-9, made its appearance. These receivers were based on the original Radiation Laboratory design, as was the ground station equipment (transmitters, pulse timers, and synchronizing equipment). Ground installations were made at Allied bases over the entire globe, from The Bay of Bengal in the west to the Mediterranean on the east, and

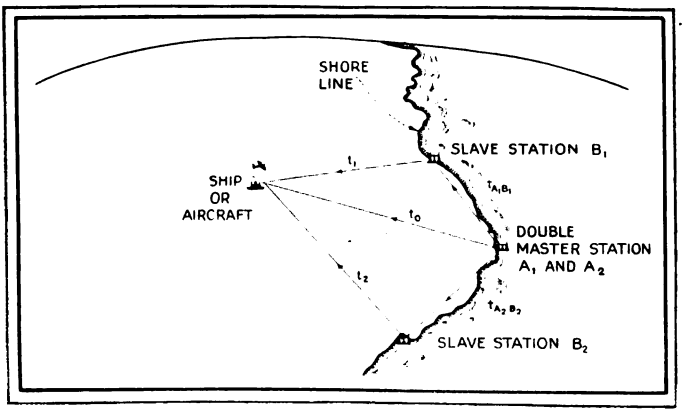

FIG. 1—Basic layout of the Loran system. Master and slave stations transmit synchronized pulses, and the difference in their times of arrival determines the position of the ship or aircraft

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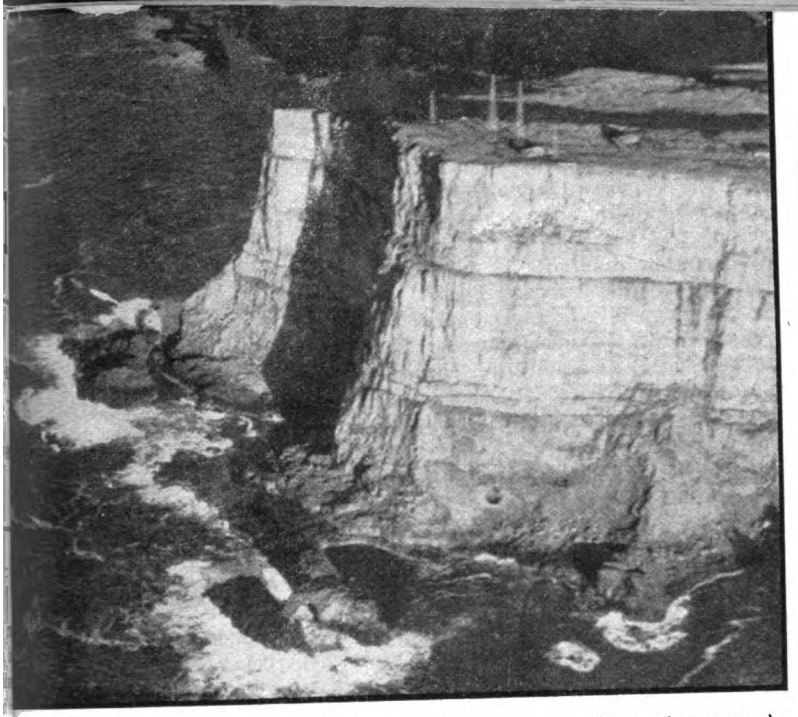
electronics WAR REPORT



Loran stations have been installed in many remote places, like this one (note towers) on top of a cliff in the Faeroes Islands

manned by personnel of the Coast Guard, Army Air Forces, Canadian Navy, British Navy, and Royal Air Force.

Credit for the development of the Loran system and all its components, as well as the study of radio wave propagation on which it is based, goes to the Loran Division of the Radiation Laboratory, a group* of approximately 50 engineers, physicists and technicians which served under the direction in successive years of Melville Eastham, Donald G. Fink, J. C. Street and J. A. Pierce. Credit for the effective use of the system by the fleets and air forces of the Allies goes to thousands of individuals in the Armed Forces who put into effect plans formulated by Major General H. M. McClelland of the U. S. Army Air Forces, Rear Admiral Joseph Redman of the U. S. Navy, and Air Vice Marshal Sir Victor Tait of the Royal Air Force.

The principle of hyperbolic navigation, as exemplified in the Loran system, is illustrated in Fig. 1. Four pulse-transmitting stations are located along a shoreline adjacent to the ocean area over which navigation is desired. Two of these stations (A_1 and A_2 in the figure) are, for economy's sake, at one point which is known as the "double master" station. This station sends out pulses broadcast in all directions, at a highly precise rate. Two sets of pulses are transmitted. One set, transmitted by station A_1, operates at a rate of, say, 25 pulses per second. The other set, corresponding to station A_2, operates at a slightly different rate, say 25.0627 pulses per second. The difference in the rates permits the two sets of pulses to be distinguished when they arrive at the ship or aircraft.

Consider first a pulse broadcast by station A_1. This pulse travels to the associated "slave station" B_1, where it is received. After a predetermined delay, B_1 sends out an identical pulse which is timed at the rate of the pulse received from station A_1. Hence stations A_1 and B_1 send out identical pulses at the same rate (in this case 25 per second), but the pulses from station B_1 are emitted later than those from A_1 by the time $t_{A_1B_1}$ (the time of travel from A_1 to B_1) plus the delay δ within station B_1. The two sets of pulses from A_1 and B_1 are transmitted to the receiver on the ship or aircraft. The pulses from B_1 arrive after an additional delay t_1 and those from A_1 after an additional delay t_0.

At the receiver the two pulses are displayed on a cathode-ray oscilloscope and the *difference* in their

WAR and POSTWAR

DEVELOPED by the Radiation Laboratory at M.I.T. in 1941-42, Loran has since served as the principal long-range navigation service of the Allied fleets and air forces.

The system currently provides precise navigational coordinates covering one quarter of the earth's surface. Representing a wartime investment of over 100 million dollars, it will continue to be operated for the use of commercial marine and air services. The British government in an unprecedented step has recently recommended that Loran be standardized internationally, in preference to other British and German systems, as the primary radio aid to transoceanic air navigation.

This article, the first of a series, describes the operating principles of the system, its basic specifications and methods of use. Following articles will describe the airborne and shipborne navigating equipment as well as the ground stations which provide the service

* Among the staff members of the Loran Division who contributed to the development and installation of the equipment are Elizabeth Cooper, David Davidson, Melville Eastham, D. G. Fink, Gordon Gregory, John Halford, D. E. Kerr, R. B. Lawrance, A. A. MacKenzie, Glenn Musselman, J. A. Pierce, J. K. Phelan, A. J. Pote, B. W. Sitterly, J. A. Stratton, W. L. Tierney, Joseph Waldschmit, J. C. Williams, and R. H. Woodward. Among the military contributors were Major J. M. Hertzberg, AAF; Commander A. S. Van Dyck, USNR; Commander J. R. Foster, RCNR; Lt. Commander Fletcher Watson, Hydrographic Office; and Captain L. M. Harding, USCG.

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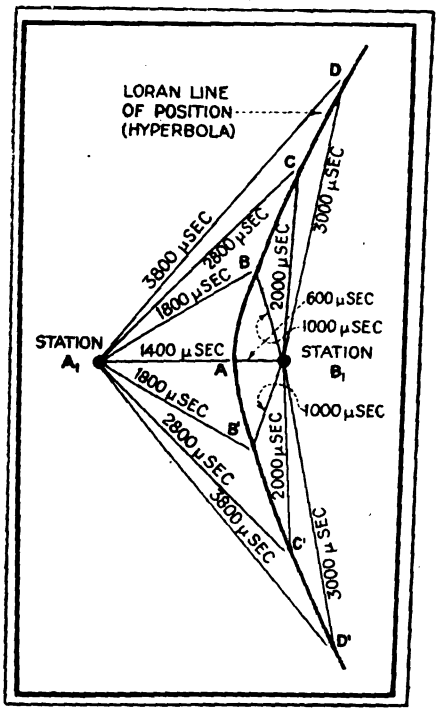

FIG. 2—Derivation of a hyperbolic Loran line (shown in red) from points of equal time difference

times of arrival is very precisely measured (to an accuracy of the order of one microsecond). The time difference so measured is equal to

$$T_{G1} = (t_{A1B1} + \delta_1 + t_1) - t_s \quad (1)$$

The quantity in brackets represents the time required for the master pulse to be relayed to the receiver via station B_1 and t_s represents the time for the master pulse to arrive directly from A_1. Using the measured value of time difference, the navigator consults a Loran chart and finds on it a line (or interpolates between lines where necessary) associated with station pair A_1B_1 and marked with the corresponding value of time difference. The ship or aircraft is located on this line.

By an exactly similar procedure, the navigator then measures the time difference between the other pair of pulses, originating in stations A_2 and B_2 and sent out at 25.0627 pulses per second. The time difference is

$$T_{G2} = (t_{A2B2} + \delta_2 + t_2) - t_s \quad (2)$$

Using this value of time difference, the navigator consults the same chart and finds (or interpolates) another line, associated with the station pair A_2B_2. The intersection of this line with the line found previously is the position of the aircraft or ship. Thus by two measurements of time difference on synchronized pulses arriving from two pairs of stations, the navigator finds his position.

If the time difference is measured precisely, the accuracy of position finding is correspondingly precise. When the time differences are measured accurately to one microsecond it is possible to determine the position to within a few tenths of a mile in the most favorable regions of the area covered, and the error in navigation is in no case worse than one percent of the mean distance of the ship or aircraft from the stations. Thus if the navigator is roughly 500 miles from shore, he can determine his position within 5 miles, and in certain areas (at this distance) he may even determine it within a mile or less. Moreover, as the navigator approaches shore and the need for precise navigation increases, the accuracy of position finding increases in proportion to the need, approaching a limiting accuracy which is well within one mile.

The relation between the time difference and the corresponding position line on a Loran chart can be seen from Fig. 2. Suppose that the navigator is at point A, between the two stations A_1 and B_1, and suppose that t_s is 600 microseconds and t_1 is 1400 microseconds. Then the time difference between the two paths $t_1 - t_s$ is 800 microseconds. Likewise, if the navigator is at point B, both times are longer (1000 and 1800 respectively) but their difference remains the same, 800 microseconds. Similarly, at points C, D, B', C', and D' the same time difference appears. The locus of these points and of all intermediate points displaying the same time difference (shown as a red line in the Figure) is theoretically a hyperbola. However, when the locus is plotted on the surface of the earth, the term hyperbola does not strictly apply and the term used is a Loran line of position, or simply "Loran line".

It will be noted that in discussing Fig. 2 we refer to the time difference $t_1 - t_s$, whereas the time difference actually measured is that given by Eq. (1). But in Eq. (1) the quantities t_{A1B1} and δ_1 are constants for any particular pair of stations, so the time differ... tually measured is $t_1 - t_s$ constant. The constant is e... and taken into account in l... the lines on the chart, and n... be considered by the naviga...

The Loran line shown in ... is one of a family of line... for each value of measur... difference there is a corres... hyperbolic locus. Such a f... shown in Fig. 3. Here th... have been labelled with the ... values of time difference, gi... Eq. (1), when the value ... slave station delay δ is 1000 ... seconds. In the case sho... value of time difference in... continuously from a low v... 1000 microseconds on the ... erate hyperbola (baseline ... sion) passing through the sl... tion B_1 to a high value of ... microseconds on the corres... line passing through the ... station A_1. It will be noted that ... line has a separate value of ... difference, and there is no ... guity. This follows from the ... difference defined by Eq. (1) ... the signals were emitted ... taneously from master and ... stations, lines at equal distan... the left and right of the center ... would have the same value of ... difference and an ambiguity w... exist. It will be noted also that ... lines shown are separated by ... tervals of 400 microseconds. ... every line shown, the system ... distinguish 400 intermediate li...

The family of lines in Fig. ... nevertheless illustrates a fund... mental shortcoming of all hyp...

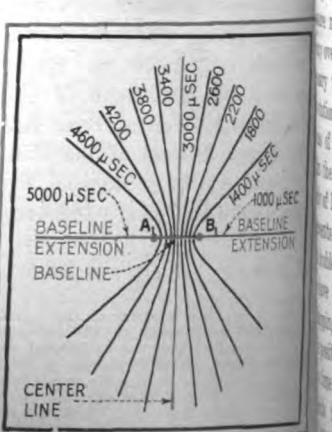

FIG. 3—Family of Loran lines. The navigator selects the line corresponding to the measured time difference, interpolating where necessary

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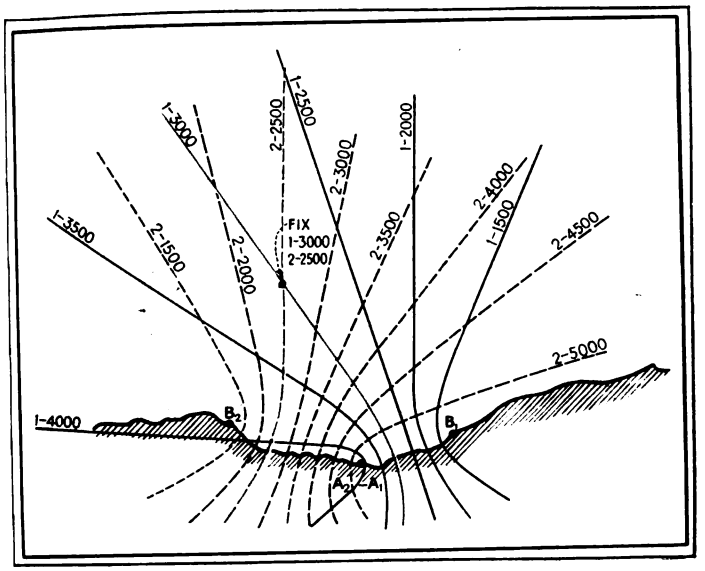

FIG. 4—Two families of lines, from two pairs of stations, overlap to form a system of Loran coordinates. The lines determine the fix (shown in red). Between adjacent lines, 500 additional lines can be resolved by the system

bolic navigation systems: the accuracy of determining the position is not constant over the coverage area. The lines are most closely spaced (and the accuracy of position correspondingly highest) along the baseline connecting the two stations. As the navigator departs from the baseline, the lines diverge. Hence the accuracy of navigation decreases with increasing distance from the stations, as already stated. Moreover, the divergence of the lines increases as the navigator departs from the center line and approaches the baseline extensions. Along the baseline extensions themselves, the accuracy of the system is poor. To assure navigation of acceptable accuracy over the desired area it is necessary to select the locations of the stations with care, so that the areas of primary interest fall within the central portion of the family of lines.

Figure 4 represents a typical arrangement of a double master station and two slave stations and shows the overlapping families of Loran lines. The position fix shown corresponds to a time difference of 3000 microseconds from station pair A_1B_1, and 2500 microseconds from station pair A_2B_2. This figure illustrates another factor influencing the accuracy of the fix, the angle at which the two lines intersect (crossing angle). In the vicinity of the master station, the crossing angle is close to 90 degrees, the optimum case. At greater distances the angle decreases and longitudinal accuracy, i.e., along the lines, is thereby reduced. However, the combined effect of all the losses of accuracy is expressed in the rule-of-thumb previously stated; the accuracy is not worse than one percent of the mean distance from the stations, and the accuracy improves as the navigator approaches the center line or the baselines, or both.

A quantitative index of accuracy is given in Fig. 5. Each line of Loran line is indicated as a zone, at the center of which is the indicated line of position and the edges of which represent the limits of uncertainty in measuring the time difference. When two such zones are crossed to find the position fix, the intersection of the zones forms a quadrilateral, shown shaded in the figure. The indicated position is the point shown in the center of the quadrilateral, but the position is uncertain over the shaded area. The maximum diagonal of the quadrilateral is a measure of the error in fixing the position. The maximum possible error is one half of this dimension.

Another way of expressing the accuracy of the system is to state the angle corresponding to the uncertainty in a line of position. This angle is directly comparable with the angular accuracy of a loop-type direction finder. In the family of lines shown (Fig. 3) there are 3200 separately distinguishable lines between the limiting parabolas, which subtend an angle, at the center of the baselines, of about 110 degrees. Hence the average angular separation between resolvable lines is about 0.03 degree, compared with one to five degrees which is the normal accuracy of a loop-type direction finder.

Distance of Coverage

After the accuracy of the system has been established, the important remaining question is the maximum distance at which the signals can be received with sufficient accuracy for the intended use.

The attenuation of 2000-kc radio signals propagated with horizontal polarization via the ground wave over sea water is approximately 10 db per 100 miles. The standard Loran pulse is fed to the antenna with a peak power level of from 75 to 100 kw, and the standard Loran transmitting antenna has a power efficiency of at least 75 percent. Under these conditions the

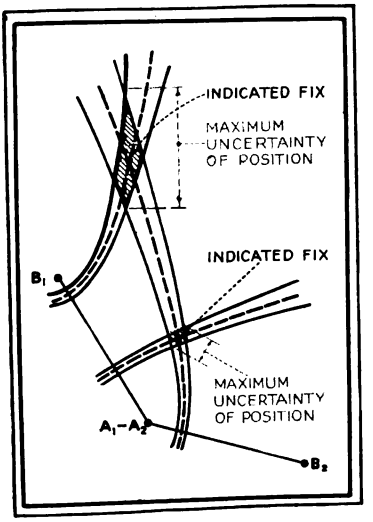

FIG. 5—Any discrepancy in measuring the time differences spreads the Loran line into a "zone." Two zones, crossed, form a quadrilateral (shown in red) within which the position lies

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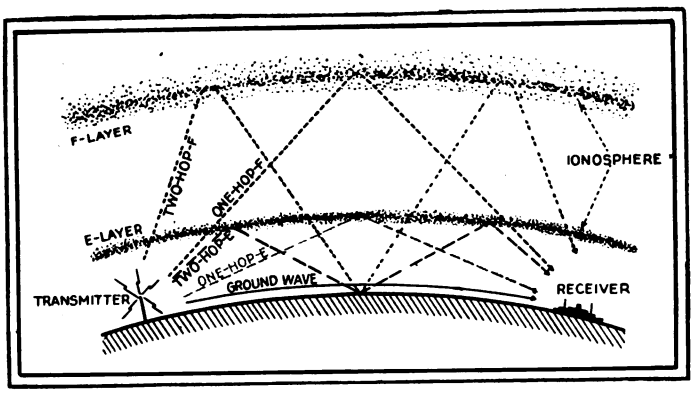

FIG. 6—Propagation of Loran signals at night via the sky wave. The "one-hop-E" reflection possesses sufficient constancy of transmission to replace the ground wave and thus extend the night-time range of the system

signal falls to a level of about 2 microvolts per meter at a distance of 750 statute miles, and this is about the minimum level on which the receiver can operate in the absence of atmospherics. At night the external noise level (originating outside the receiver) increases and the maximum useful range via the ground wave is reduced to about 500 statute miles. In exceptional circumstances, noise may reduce the range to smaller values, and precipitation static encountered in aircraft may obliterate the signals even within a few miles of the station. But for 95 percent of the time, the reliable range using the ground wave is 750 miles by day, 500 miles by night.

Early in the development of the system, Melville Eastham suggested that the sky wave signal might be employed at night to extend the range and this thesis was first proved by a series of several thousand observations made by J. A. Pierce at Bermuda early in 1942. Since the pulses employed in the system are short, the several signals reflected from the ionosphere are discernible separately, and it was possible to investigate the constancy of transmission of signals reflected from the several ionospheric layers. The early investigations showed that a singly-reflected signal from the E-layer of the ionosphere was transmitted with remarkable constancy. The E-layer signals displayed some fading and variations in shape, but were sufficiently stable to allow the time difference to be measured to an accuracy of the order of five microseconds. The same investigation showed conclusively that reflections from the F-layers of the ionosphere were much less stable, not only in the time of transmission but also in the constancy of pulse shape.

This discovery of an hitherto unsuspected property of sky wave transmission made it possible, at night, to double the range of the system by employing singly-reflected E-layer signals. The height of the E-layer is about 60 miles, so a wave leaving the earth tangentially is refracted back to another point of tangency at a distance of about 1600 statute miles. At distances beyond this only doubly or multiply-reflected E-layer signals can be received and these are generally so weak, or so inconstant in transmission, that they were not believed to have utility in a system intended for use by the Armed services. Accordingly the limit was set at 1500 miles, and the Loran charts and tabulations of time difference were prepared to cover this range from the stations.

The mechanism of the propagation of the sky-wave is shown in Fig. 6. The "one-hop-E" signal is the sky wave signal used. It will be noted that this signal takes an additional length of time to travel from transmitter to receiver, relative to the ground wave. This "sky wave delay" must be taken into account in using the system. Specifically, a sky wave correction of a specified number of microseconds is computed for each portion of the chart and this correction added to or subtracted from the observed reading of time difference before entering the chart to find the Loran line. Figure 7 gives the average values of the singlehop E-layer sky wave delay in microseconds (as measured over the winter of 1942-43) for various distances between transmitter and receiver. The appropriate values of delay are added to the ground wave transmission times t_1 and t_2 (see Fig. 1) in computing the sky wave time difference. The difference between the sky wave time difference and the ground wave time difference (the latter being given by Eq. (1)) at the given point is the sky wave correction which is applied as previously stated.

Sky wave transmission is generally available at 2000 kc only at night, although at distances beyond 500 miles the sky wave signals are often seen on Loran oscilloscopes in the early morning and late afternoon hours. Where military operations are scheduled for the night hours (for example night-bombing missions), the sky wave may be relied upon not only for reception at the ship or aircraft but also for synchronizing the pairs of stations. When sky waves are so employed for synchronization, the system is known as SS Loran ("SS" for sky-wave synchronization). Since the sky waves are propagated over land with almost negligible attenua-

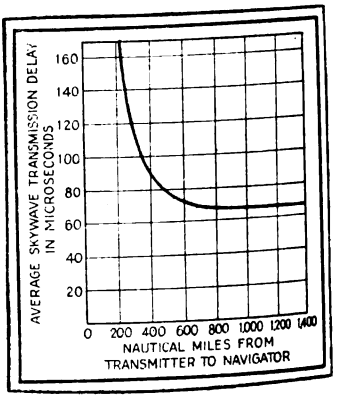

FIG. 7—The additional time of transmission of the "one-hop-E" sky wave, relative to the ground wave, over various distances. This delay is applied as a correction when using sky-wave signals with ground-wave charts

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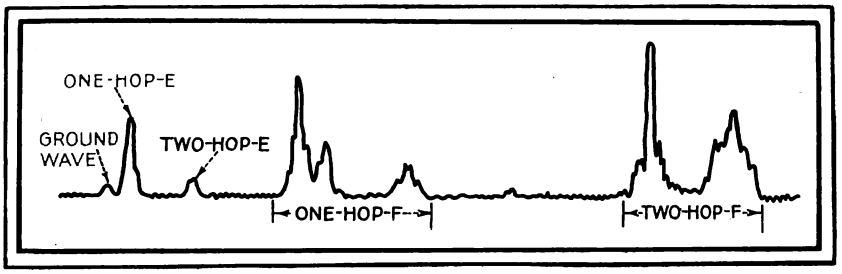

FIG. 8—Typical ground-wave and sky-wave pulse sequence as observed on the Loran oscilloscope. Signals to the right of the one-hop-E are disregarded by the navigator

tion, it is possible to set up an SS system for navigation over land areas. The first such system was set up over Germany, using stations in Africa (later Italy) and Scotland. It provided accurate coverage over the entire region of occupied Europe from the summer of 1944 to the end of the war. This system was used by the British night bomber force, and was sufficiently accurate to permit blind bombing over Berlin.

Figure 8 shows a typical sequence of pulses as they are observed on the cathode-ray trace of the Loran indicator. It is evident that the navigator must identify the proper pulse before measuring the time difference, and this constitutes a problem in the application of sky waves. When within range of the ground wave, the first pulse to appear is the ground wave, which is generally considerably weaker (because of the higher attenuation) than the following sky waves. The next after the ground wave pulse is the one-hop-E pulse, since it arrives by the next shortest path. If the navigator is just beyond the range of the ground wave the first pulse seen is the one-hop-E, and this pulse must be matched with the corresponding pulse from the other station of the pair. Experience in operation has proved that a navigator soon becomes accustomed to the sequence of pulses shown and is generally able to distinguish the ground wave from the sky waves and the one-hop-E wave from the other sky waves.

How the Time Difference is Measured

Figure 9 shows the method by which the navigator measures the time difference. The cathode-ray indicator displays two horizontal traces which are formed, in succession with invisible retrace lines, as shown. The traces are formed under the control of a quartz-crystal oscillator which is adjusted to exact synchronism with the incoming pulses, say those from station pair A_1B_1. In the case we have cited (Fig. 1) the pulse rate for A_1B_1 is 25 pulses per second, so the time from the beginning of the top trace through the entire pattern and back to the beginning of the top trace is exactly 1/25th second, and each trace is approximately 1/50th of a second long. The pulses, being synchronous with the traces, appear as stationary vertical lines, as shown in the Figure.

Auxiliary "pedestals," created by circuits within the indicator, are used as index marks. By adjustment of the crystal-control circuit, the pulses are moved until one pulse falls on the top pedestal. The bottom pedestal, controlled by an adjustable delay circuit, is then moved under the bottom pulse. The relative positions of the two pedestals are then adjusted, by a series of expanded sweeps, (details of which will appear later in this series) until they are oriented with the incoming pulses to an accuracy of one microsecond. The time delay between the formation of the pedestals is then measured by calibration pulses derived from the crystal control. This is the value of time difference associated with stations A_1B_1. A similar measurement is performed on the pulses from station pair A_2B_2 by adjusting the cathode-ray deflection circuits to be synchronous with the rate for that pair, namely 25.0627 pulses per second.

In all, 14 pulse rates are available in the indicator, eight rates being slight variations of 25 pulses per second, and the remaining six being variations of 33⅓ pulses per second. In addition, three radio frequencies, 1750, 1850, and 1950 kc, are available (1900 kc was also used in the SS system) so a wide choice exists in the selection of pairs of stations. Theoretically 14 x 3 = 42 pairs of stations can be accommodated in any one interference area (about a 2000-mile radius) and the whole group can be duplicated in another non-adjacent area. In this manner it is possible to provide widespread coverage without requiring any more than 300 kc of ether space. In post-war applications, only 1850 and 1950 kc will be used, according to the Loran band proposed for international standardization at the Rio de Janeiro conference last month. —D.G.F.

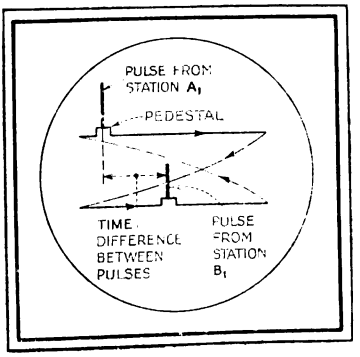

FIG. 9—Basic Loran oscilloscope pattern. By orienting the pulses with the pedestals, and measuring the time between pedestals, the time difference is determined. Expanded sweeps are required to obtain one-microsecond accuracy

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Non-Metallic

Disturbances to ground during planting of plastic or other non-metallic mines change the dielectric constant enough to actuate detector set AN/PRS-1, also highly effective for metallic mines. Complete technical details and suggested peacetime industrial applications are given

By T. E. STEWART
Applied Electronic Branch
The Engineer Board
Fort Belvoir, Virginia

Detector set in operation. Operator is using headphones, as required in locations where ambient noise level is high or silence requirements prohibit use of the loudspeaker-type resonator

DURING 1942, German forces began to use anti-tank mines that were completely non-metallic in construction. The incidence of these mines became so great that an urgent requirement was established for a detector of non-metallic mines. This problem had been anticipated and development of appropriate non-metallic detecting equipment had been under way as a phase of the overall mine detection problem.

The resultant new detector set AN/PRS-1 reacts to both non-metallic and metallic mines. The device consists primarily of a 300-megacycle oscillator and its associated antenna system. Buried objects, such as non-metallic and metallic anti-tank mines, are indicated by both aural and visual means, the same adjustment of the detector being used to detect either or both types of mines. Aural indications of mines are provided by a 1000-cycle audio resonator or a standard headset. Visual indicating means are provided by a 0 to 150-microampere meter mounted on the detector exploring rod. The detector set is carried and operated by one man.

The detector is generally capable of indicating the presence of the standard American non-metallic or metallic anti-tank mines at depths of 0 to 5 inches, depending upon the conditions of the soil in which the mines are buried. In general, water-saturated soils limit the depth of detection to fractions of an inch for both types of mines, depending on the depth of surface water. Extremely dry soils of high resistivity completely mask the presence of the non-metallic mines but allow detection of the metallic mines in the normal manner. Soils of intermediate characteristics allow normal operation.

Detector set AN/PRS-1 responds to changes in the average dielectric characteristics of the soil over which it is being operated. Because of the frequency of the generated signal (300 mc) non-uniformities in the ground generally must be at least 5 inches long, 2 inches wide, and 1 inch deep before detector response is obtained. Indications then will be derived from objects such as boulders, tree roots, and voids (air pockets). The visual and aural indications obtained from such discontinuities may be similar to those produced by a non-metallic or metallic mine, depending upon the dimensions of the non-uniformity and the depth at which it occurs. A trained operator can learn to recognize the characteristics of the signals produced by many of these discontinuities and treat them properly.

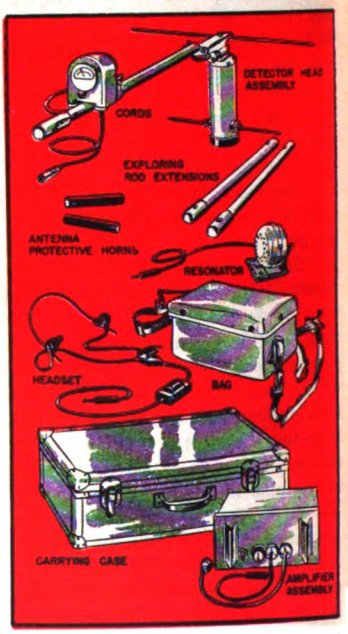

FIG. 1—Main components of detector set AN/PRS-1

The main components of detector set AN/PRS-1 are illustrated in Fig. 1.

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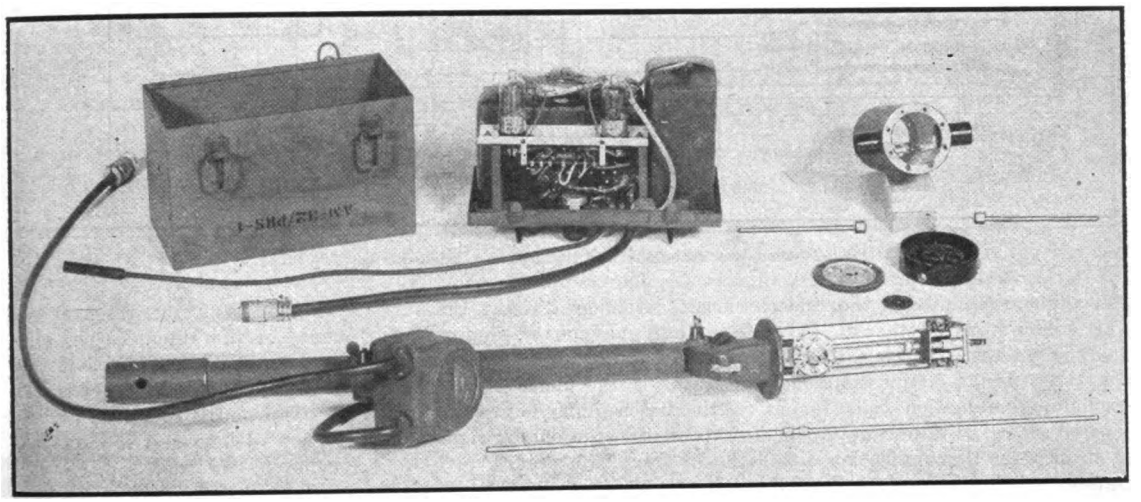
Mine DETECTOR



Set disassembled to show construction. A 6-volt filament battery and 90-volt B battery supply power for the three tubes. Total weight is only 23 lb

Main Components

The detector head assembly includes the detector head with antenna and reflector, and the meter and meter housing. These units are attached to the lower section of the exploring rod and are adjustable. The antenna and reflector are removable, and a control located at the bottom of the detector head furnishes a means of tuning and loading the oscillator. The detector head assembly is connected to the amplifier assembly by a cord equipped with a five-connector male plug.

The antenna protective horns are constructed of a low-loss thermoplastic tubing. These horns fit over bosses mounted on the detector head case and are used to cover the transmitting antennas, protecting them from high weeds, brush, and rain.

The exploring rod extension is an aluminum tube designed for attachment to the detector head assembly rod by means of a ball-detent joint. Two extensions are supplied to afford an optimum exploring range.

The amplifier assembly consists of the audio oscillator, the amplifier, and two short cords. One cord, which terminates in a five-connector female plug, is used to connect the amplifier to the detector head assembly. The other cord terminates in a phone jack for connection to the headset or resonator. Located on the bottom of the amplifier housing are the volume control and on-off switch. Two base legs are provided on the bottom of the amplifier to protect the controls. Space for the batteries is provided within the amplifier housing. The controls, cords, and amplifier housing are of immersion-proof construction.

Electronic Circuits

The complete circuit is given in Fig. 2. The ultrahigh-frequency oscillator mounted in the detector head is of the resonant line type, operating at a frequency of approximately 300 mc. A 50-$\mu\mu$f capacitor, used as a resonant line shunt, is made externally adjustable by means of the tuning knob at the bottom of the detector head assembly. An antenna coupling loop is mounted in the detector head case, providing coupling from the oscillator to the antenna system. The coupling loop is shunted by a resistor chosen to maintain the antenna impedance at the value required for operation.

The radiating dipoles are provided with tapped bosses to fit the studs on the detector head case at which the antenna coupling loop terminates. Provision is made on the detector head assembly to mount a reflecting dipole to increase the signal in the ground over which the detector is being operated. A 3,200-ohm grid resistor is connected in series with the detecting meter to ground. The variations in grid current registered on the detecting meter during operation are used as the visual indicating means. The variations in direct voltage across the grid resistor during operation are applied through a 15,000-ohm resistor to the grid of the output tube of the a-f amplifier to provide variations in audible signal output.

The amplifier assembly contains

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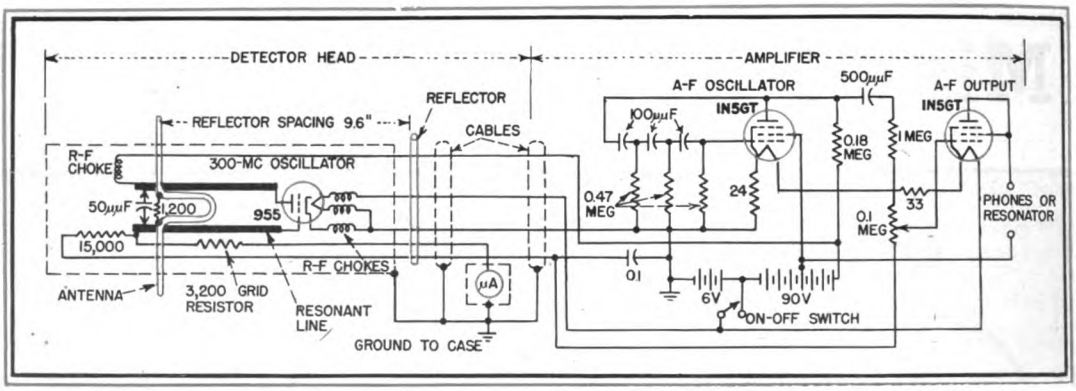

FIG. 2—Complete schematic circuit diagram of detector set AN/PRS-1

a two-tube a-f oscillator- amplifier. The oscillator is of the *RC* type using an untapered phase shift network. A redesign of this amplifier-oscillator combination calls for a tapered phase shift network to be used, in order that oscillation difficulties with low-gain 1N5GT tubes be reduced. The amplifier tube filaments are connected in series with 24 and 33-ohm resistors across a 6-volt filament supply to provide bias for the phase-shift oscillator and reduce the number of batteries required in the detector. A potentiometer is provided in the amplifier to adjust the audio signal initially to the desired level.

Theory of Operation

In Fig. 3A the oscillator is shown coupled to a dipole antenna over homogeneous earth. Radio-frequency current flows from the oscillator to the antenna and along the antenna. A portion of the current flows through space from one side of the antenna to the other as capacitance current. Another portion of the current flows from the right-hand side of the antenna to the earth as capacitance current, through the earth as capacitance and conduction current, and from the earth to the left-hand side of the antenna as capacitance current.

At the operating frequency of the detector (300 mc) the current flow through the earth is equivalent to capacitive current flow through a poor dielectric. If the dielectric constant of a discontinuity in the ground is less than that of the surrounding medium, as in Fig. 3B, an increased amount of current will flow through the surrounding medium, causing an increase in antenna resistance and reactance. If the dielectric constant of the discontinuity is greater than that of the surrounding medium the inverse effect occurs.

Over normal ground the resistance to capacitive flow does not change appreciably when the height of the antenna above ground varies between 2 and 5 inches. However, the presence of a non-metallic mine does measurably change reactance in this region. The change in reactance in the presence of a mine tends to be negative. If the oscillator is tuned to a frequency higher than that of the antenna, the presence of a non-metallic mine brings the antenna into resonance with the oscillator, thus loading the oscillator heavily and decreasing the amount of grid current flow. If the oscillator is tuned to a frequency lower than that of the antenna this change in reactance tends further to reduce the oscillator loading, with no appreciable resultant effect on the oscillator grid current. The presence of metallic mines buried at operational depths in normal ground tends to decrease antenna loading, causing a decrease in oscillator loading and a consequent increase in grid current flow. In the case of metallic mines this increase in grid current is usually by a factor of 2.

Adjustment Procedure

The parameters of the high-frequency oscillator and antenna loading loop are so chosen that the operating frequency of the oscillator is higher than the resonant frequency of the antenna. The coupling loop is shunted by a resistor (of selected high-frequency characteristics) and is retained in a fixed position with respect to the oscillator lines. The oscillator frequency is adjusted, by means of the resonant line shunt capacitor, from the high-frequency side of resonance of the antenna system towards resonance. This is accomplished by manipulation of the tuning knob at the bottom of the detector head assembly.

Proper adjustment is obtained when approximately 80 microamperes of grid current flows in the oscillator circuit when the detector head is held approximately 3 inches above the ground. The presence of a non-metallic mine then causes the grid current to drop to that value established by the contact potential of the tube (usually 10 or 15 microamperes). The presence of a metallic mine unloads the oscillator, causing a substantial rise in grid current (usually in excess of 150 microamperes).

The decrease in grid current causes a drop in the d-c potential across the grid resistor, which is coupled to the amplifier output tube control grid. The decrease in control grid voltage on the a-f output tube in the amplifier causes an increase in the audio signal output. The inverse effect occurs when the oscillator grid current increases. The audible signal is initially adjusted to a satisfactory level, the presence of a non-metallic mine causing the signal to increase in amplitude, and a metallic mine causing the signal to cut off.

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During the development of this detector it was determined that the incremental variations obtained from the grid current flowing in the high-frequency oscillator tube were more usable and greater than those changes occurring in the plate circuit. The normal grid current drawn by the type 955 tube oscillating in the unloaded condition is in the order of 5 milliamperes, at 300 mc. As previously indicated, the grid current flowing during operation is in the order of 80 microamperes. High efficiency must be obtained from the oscillator to maintain regeneration under the severe loading conditions imposed upon it.

Technical Considerations

The characteristics of the oscillator tube under the operating condition determine to a great extent the successful operation of the oscillator as a mine detector. For this reason, a great many type 955 tubes do not allow operation of the oscillator under the loading conditions required. It was found necessary to select the tubes used in the high-frequency circuit during production. The choice of the 955 tube for use in the detector circuit was based upon the availability of this type, its high-frequency characteristics, and its measurable grid current under the operating conditions required. The use of this tube required that a substantial filament and plate battery supply be used in the detector in order that a reasonable operating time be obtained between battery changes.

Operation

Detector set AN/PRS-1 is carried and operated by one man. The total weight is 23 pounds, the amplifier weighing 15 pounds and the exploring rod assembly 8 pounds. The operator initially mounts the two tapped dipoles and the reflector on the detector head assembly. The proper cable connections are made to the amplifier and headset or resonator. The choice of resonator or headset is left to the operator. In general, the resonator is more comfortable to the operator than the headset, its use being determined by the necessity for quiet operation or the level of ambient noise.

The detector is turned on by means of the switch mounted on the amplifier. Approximately 30 seconds is required for the 955 tube to reach cathode operating temperature. With the detector head held well above the ground, the tuning knob at the bottom of the detector head assembly is turned clockwise to the extent of its travel so that the oscillator is operating at its highest frequency. The tuning knob is then turned counter-clockwise until the detector meter reads approximately one-half full scale (approximately 80 microamperes). The detector head is then presented to the ground and the tuning knob is turned counter-clockwise until

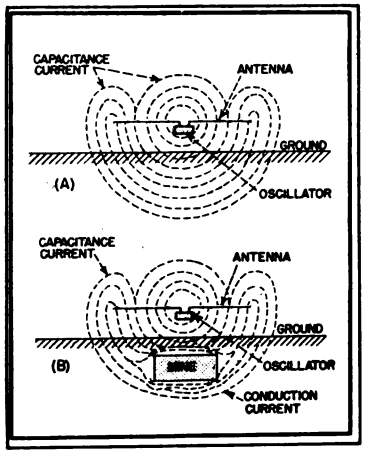

FIG. 3—Manner in which buried metallic or non-metallic mine affects 300-mc r-f conduction currents through earth. These in turn react on capacitance currents that pass through space and change the grid current of the r-f oscillator

no deflection of the meter occurs until the detector head is within 8 inches of the ground. The knob is adjusted until the detector meter reads half-full scale at a height of approximately 3 inches from the ground. The detector oscillator is then operating under the condition necessary for the detection of both non-metallic and metallic mines.

The potentiometer on the amplifier case is adjusted, with the detector head held in the operating position, until a nominal audio signal is heard. The detector operator then moves the detector head from side to side, advancing approximately 1 foot per sweep. For proper operation the height of the detector head above ground is maintained between two and five inches. Over normal soils and with mines buried at operational depths, metallic mines increase the meter reading and decrease the audio signal, and non-metallic mines decrease the meter reading and increase the audio signal.

Future Use

Detector set AN/PRS-1 or modifications of this detector may be used to detect the presence of non-metallic masses buried at shallow depths in the ground. Modifications could be used to detect the presence of metallic masses of finite dimensions in non-metallic objects, while discriminating against objects of smaller size.

The presence of voids or discontinuities in plastic objects could be determined by a modification of this detector. When the device is adjusted off resonance it is capable of detecting the presence of personnel or vehicles in motion at ranges up to 100 feet. Such an application might be valuable in plant protection or machine safety installations where space limitations or arrangement preclude the use of a separate source and receiver combination, or where ambient noise or light prevent the use of audio or photoelectric systems.

Acknowledgments

Initial research and development work on detector set AN/PRS-1 was carried out by the Radio Corporation of America, RCA Victor Division, Indianapolis, Indiana, and the RCA Laboratories, Princeton, New Jersey. Because of the difficulties arising during initial production and testing of the first models of the detector set, additional developmental work was carried out at the Engineer Board. The work was directed and coordinated by the War Department, The Office, Chief of Engineers, Engineer Board, Fort Belvoir, Virginia and the National Defense Research Committee. The Engineer Board is directed by Brigadier General John W. N. Schulz, President, with Colonel W. J. Matteson as Executive Officer.

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The SCR-584 Radar

---Part I---

The most versatile of the ground-based radars, SCR-584 stopped the buzz bombs by guiding antiaircraft batteries automatically to an accuracy of 0.06 degree. Technical features include conical scanning, 300-kw pulses at 10-cm wavelength, and range-timing accuracy to 0.01 microsecond

HIGH on the list of the electronic achievements of the war is the SCR-584 radar. A microwave set developed primarily for accurate fire control of 90-mm anti-aircraft batteries, the 584 served this basic purpose from Anzio to the end of the war. It also served as an early-warning radar against approaching enemy aircraft, as a ground control for low-flying fighter aircraft in the advance across France, and detected the motion of enemy transportation along roads and the flight of enemy shells and mortars in the Italian campaign. Technically, also, SCR-584 merits a high place. It is among the most powerful of the portable radars, and is outstanding in the accuracy of its indications. In short, this radar is one of the most highly-engineered electronic devices in existence.

The need for a radar to control the fire of anti-aircraft guns was felt before the war, and the SCR-268 (ELECTRONICS, September 1945, page 100) was applied to this use in the early days. But greater accuracy, obtainable only by the use of shorter wavelengths, was required. The military needs were presented to the Radiation Laboratory at M.I.T. by the Coast Artillery Corps (then the parent body of the Anti-aircraft Command) in January, 1941. By April, the prototype equipment had been erected on the roof of Building 6 at M.I.T. and was successfully tracking aircraft the following month. Since the need for portability was evident, the equipment was then transferred by the Radiation Lab group to a truck, known as XT-1, and demonstrated in November of the same year.* After coordination at the Signal Corps Laboratories, the XT-1 was given its service test by the Coast Artillery at Fort Monroe in February 1942. This test having been passed successfully, manufacturers were called in to bid on production and a year later, in May 1943, the first production model of SCR-584 was delivered to Camp Davis. Its first active service was at the Anzio beachhead in February 1944. In all, no fewer than 1,710 SCR 584 radars

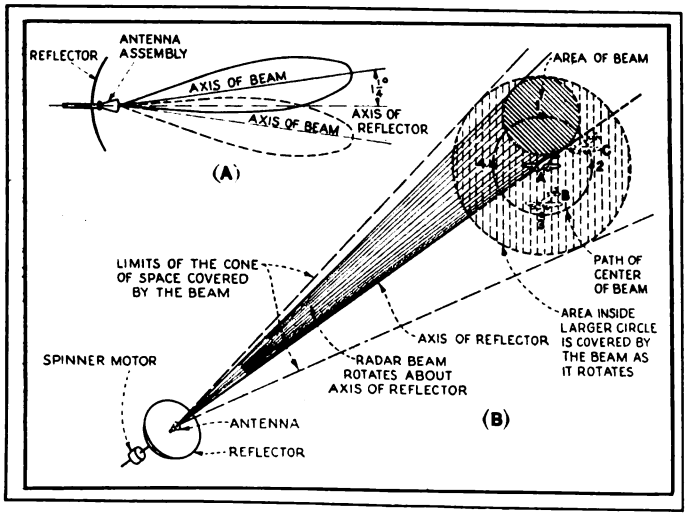

FIG. 1—(A)—Conical scanning is obtained by rotating an offset beam about the axis of the reflector. (B)—The effect of conical scanning is to create a sinusoidal error signal when the target lies off the axis of the reflector

*Among the personnel at the Radiation Laboratory and in military organizations who contributed to the design and production of the SCR-584 are: H. B. Abajian, Col. W. S. Bowen, B. Chance, L. L. Davenport, H. D. Doolittle, I. A. Getting, Sidney Godet, A. Grass, D. T. Griggs, G. B. Harris, C. E. Ingalls, Col. J. E. McGraw, L. N. Ridenour, C. W. Sherwin, Lt. Col. J. A. Slattery, L. J. Sullivan, A. H. Warner, and the late Lt. Col. Paul Watson.

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Production model SCR-584 in operation at 68th CA (AA) Bn (C Battery) in the Nettuno Area, Italy, for antiaircraft gunfire control, camouflaged against detection and sandbagged for protection

The original model, developed and built in the Radiation Laboratory in 1941 and known as XT-1. This was the first radar capable of following a target automatically without human aid

were delivered, at an average cost (including spare parts) of approximately $100,000 each.

Basic Specifications

The specifications of the SCR-584 are listed in the accompanying table, the significance of the data being discussed in other pages of this issue. By the use of 300-kw pulses of 10-cm radiation, transmitted from a 6-foot paraboloidal reflector, the SCR-584 is designed to track (i.e., follow continuously) individual aircraft out to 18 nautical miles, and detect them at 40 miles. Actually it can track aircraft at 50 miles if required. While tracking, the target position is indicated within plus or minus 25 yards in range, and 0.06 degrees in azimuth and elevation. The range indication, while looking at a stationary target, may be reset to an accuracy of 2 yards, which represents a timing accuracy of about 0.01 microsecond. The key to this outstanding performance lies in the use of conical scanning for angular determination of the target position and a quartz-crystal oscillator for timing the echoes. The use of a short pulse (0.8 microsecond long) and an expanded cathode-ray sweep permits the echo pulses to be measured precisely.

Two forms of scanning (the motion of the radiated beam through space) are employed: helical scanning and conical scanning. In helical scanning, employed for searching for aircraft before they come within range of the guns, the paraboloid is swung in a circle at a rate of 6 rpm. Simultaneously the reflector is tilted in the vertical angle (elevation) at a rate of about 4 degrees per turn. A point on the beam thus traces out a helical path, from about 10 degrees below the horizontal to the zenith, over any 20° sector. Since the beam itself is 4 degrees wide (7 degrees when the conical scanning is in operation) all points of space are passed over by the beam during each full helical scan. If an aircraft target is within range, the radar will surely detect it.

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SPECIFICATIONS

Wavelength	10-11 cm
Frequency	2,700-2,900 mc
Reflector	6-foot paraboloid
Pulse Power	300 kw
Pulse width	0.8 microsecond
Pulse rate	1,707 pps
Receiver bandwidth	1.7 mc
Receiver noise figure	15 db
Beam width	4 degrees (not spinning)
Beam width	7 degrees (spinning)
Search scan	6 rpm helical
Track scan	1,400 rpm conical
Azimuth range	360 degrees
Elevation range	−10 to +89 degrees
Maximum range, search	40 miles
Maximum range, track	18 miles
Minimum range	500-1,000 yards
Range accuracy	±2 yd (dynamic)
Range accuracy	±2 yd (static)
Angular accuracy	±1 mil = 0.06 degree

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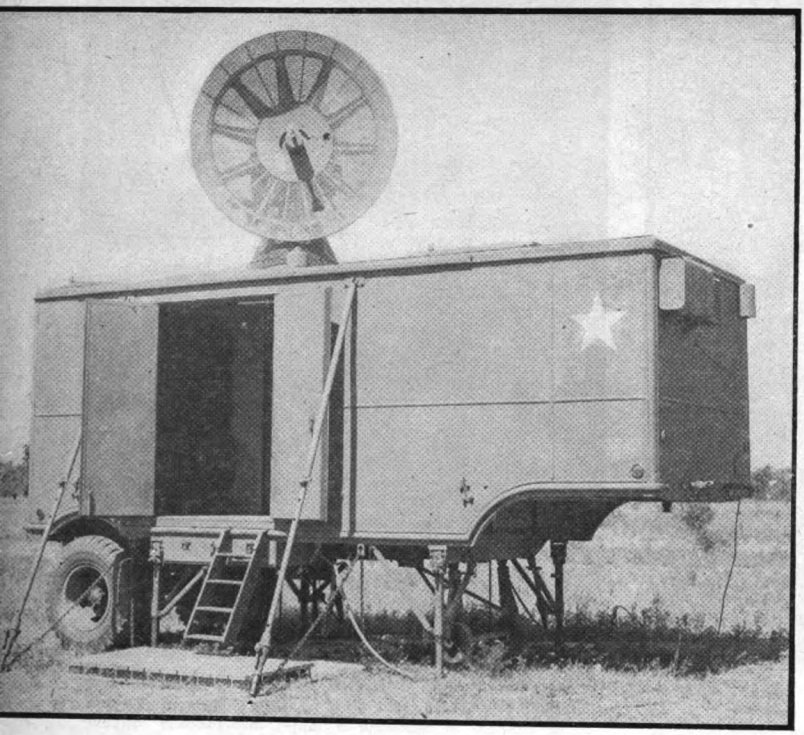


Overall view of the SCR-584. The paraboloid can be lowered into the trailer during transportation

Once the target is detected and is within range of the guns the radar function is shifted from search to track. In tracking, the axis of the antenna points automatically and continuously at the target, while the radar transmits range and angular data to the associated gunfire computer. This automatic function is accomplished by the use of conical scanning, illustrated in Fig. 1A. The radiation is off-set electrically from the focus of the reflector and the dipole radiator is rotated about the focus by an auxiliary motor at a rate of 1400 rpm. The offset causes the axis of the radiated beam to depart from the axis of the paraboloid by about 1.25 degrees, and as it rotates, the beam traces out a cone as shown.

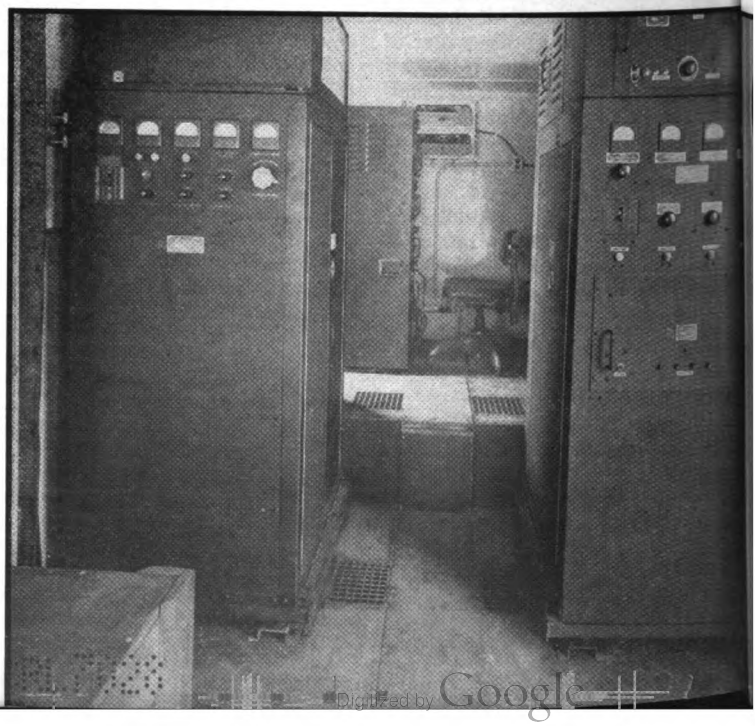
When the target lies on the axis of this cone (at point A in Fig. 1B) the signal intercepted has a constant value throughout the rotation. Consequently the reflected pulses are of constant amplitude, except for changes due to fading, polarization effects, etc. But if the target is off this axis, say at point B, the signal intercepted is a maximum at position 3, a minimum at position 1 and has intermediate values at positions 2 and 4. The variation in the intercepted and reflected signal is approximately sinusoidal, with a frequency equal to the rotation rate. Finally, if the target is at position C, the same sinusoidal variation occurs, but is shifted 90° in phase relative to that of position B. When the target has some intermediate position between B and C, the phase angle has a corresponding intermediate value.

The reflected pulses are thus modulated in amplitude. The amplitude of the modulation increases as the target departs from the axis of the cone, and the phase angle indicates the direction of the departure. By translation of these quantities into appropriate motor controls the antenna is directed so as to keep the target centered on the axis of the cone. So sensitive is this control that a departure from the cone axis of a few hundredths of a degree is immediately perceived and corrected. Moreover, the hunting of the radiator while following the target position is restricted to a probable error of one mil, or 0.06 degree.

General Operating Principles

The components of the SCR-584 are shown in the block diagram in Fig. 2. The operation starts in the timing unit, which contains a crys-

Looking forward in the trailer, the 22-kilovolt rectifier is at the left, and the modulator (including magnetron transmitter) at the right. These two units develop pulses of 300-kw peak power at a rate of 1707 per second



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tal oscillator and four frequency-dividing multivibrator stages which produce the basic pulse rate of 1,707 pulses per second. Several waveforms are generated in the timing unit to initiate the transmitter pulses and to synchronize the receiving and indicating systems with them. Narrow trigger pulses are fed to the transmitting system which comprises a driver, modulator, and r-f generator (cavity magnetron). R-f pulses of 0.8 μsec width, 3,000-mc frequency, and 300 kw peak power are generated every 586 microseconds in the transmitting system and applied through the co-axial transmission line to the antenna. On their way to the radiator, the pulses pass an enclosed low-pressure spark gap known as the transmit-receive switch (T/R box). This gap breaks down during each pulse and short-circuits the transmission line to the receiver, thus preventing the transmitter pulses from burning out the crystal mixer of the receiver.

The pulses continue to the radiator, passing concentrically through the shaft of the spinner motor which rotates the antenna to produce the conical scan. After reflection from the target the pulses are received by the same antenna and return along the same transmission

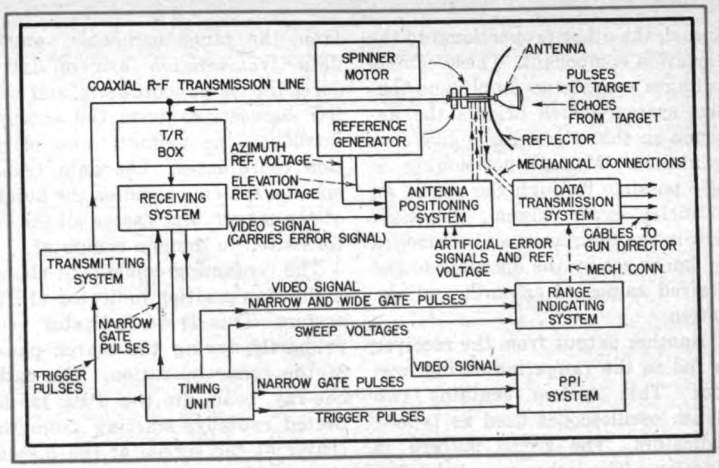

FIG. 2—Block diagram of the SCR-584. Details of the transmitting system are included in this article; other elements are in articles to follow

line. The transmitter is then inactive and its impedance is different from that of the transmission line. Consequently, little of the received signal is absorbed by the transmitter. The T/R spark gap has by then ceased conduction, so the transmission line conducts the signal to the receiver. Here it is converted in a silicon-crystal mixer to an intermediate frequency of 30 mc, amplified, detected, and amplified again as a video control signal. Pulses are fed to the receiver from the timing unit to bias the i-f amplifier during the transmission of the pulse, as additional protection against overload.

The video output of the receiver is fed to three units. The first is the antenna positioning system which compares the error signal (the amplitude modulation envelope of the received pulses) in phase and amplitude with reference voltages derived from a reference generator mounted on the spinner shaft. This comparison develops two control voltages, one proportional to the azimuth component of the error

The SCR-584 units. The two oscilloscopes at left of center are the type J indicators used in measuring the distance to the target. The dials at the right indicate the azimuth and elevation angles at which the antenna is pointing. The inclined screen is a PPI indicator which shows simultaneously the positions of all aircraft targets out to 40 miles

signal, the other proportional to the elevation component. These control voltages operate an amplidyne control system which orients the antenna so that the error signal is a minimum. Manual positioning is also possible through the use of an artificial error signal, produced within the equipment and controlled by knobs set by the operator to the desired values of azimuth and elevation.

Another output from the receiver is fed to the range indicating system. This system contains two 3-inch oscilloscopes used as type J indicators. The sweep pattern is circular. The echo signal is displayed as a radial pulse on the trace. One scope covers a range of 2000 yards for fine indication of the range, and the other covers 32,000 yards for coarse indication. The circular sweep is provided by sweep voltages derived from the timing unit.

The range indicating system is used primarily as an adjunct to automatic operation. The operator adjusts the tracking handwheel so as to keep the echo pulse on the calibration hairline. The range unit includes a mechanical aided-tracking device which maintains a given rate of change of range to keep up with the target, while the operator feeds in occasional corrections to the rate. A mechanical connection from the range handwheel to the data transmission system introduces the range coordinate, and similar connections from the antenna introduce the azimuth and elevation coordinates. The data transmission system computes the height of the target, and passes all the information to the gun computer.

The remaining component shown is the plan position indicator (PPI) system. This is an indicator used primarily during the search phase of the radar operation. The cathode-ray beam in the PPI is deflected radially, starting from the center of the screen at the instant the transmitted pulse leaves the radar and continuing outward at a constant rate. The sweep rotates synchronously with the antenna as it scans in azimuth. When an echo is received from a target, the c-r beam is brightened and a spot appears on the trace representing the target. The distance of the spot from the center of the tube indicates the slant range of the target and the direction of the trace indicates the azimuth angle to the target. The PPI thus presents a map of the area surrounding the radar, with all targets within range shown in their relative positions, in plan view. The deflection currents are generated within the PPI system, and are synchronized by trigger pulses from the timer unit.

The Transmitting System

The transmitting system block diagram is shown in Fig. 3, and simplified schematics of the driver and modulator are shown in Fig. 4 and 5. The driver unit is controlled by a short, sharp trigger pulse of 15 volts amplitude derived from the timer unit (as indicated later in this series of articles). These pulses drive a one-shot (biased) multivibrator (6SN7GT tube) which generates a negative rectangular pulse of two microseconds duration. This is fed to a 6L6G inverter stage which reverses the polarity and applies the pulse, in positive polarity, to the first driver stage (type 3E29).

The first driver is coupled by a pulse transformer (capable of passing short pulses) which reverses the polarity, feeding positive pulses to the second driver stage. The negative pulse appearing in the output of the second driver stage (two type 3E29) is fed back to the grid of the first driver through a low-pass filter network which serves as an artificial transmission line. The constants of this line are so chosen that the pulse requires exactly 0.8 microsecond to pass through the line. Consequently 0.8 microsecond after the pulse is applied in positive polarity to the first driver, a large negative pulse is fed

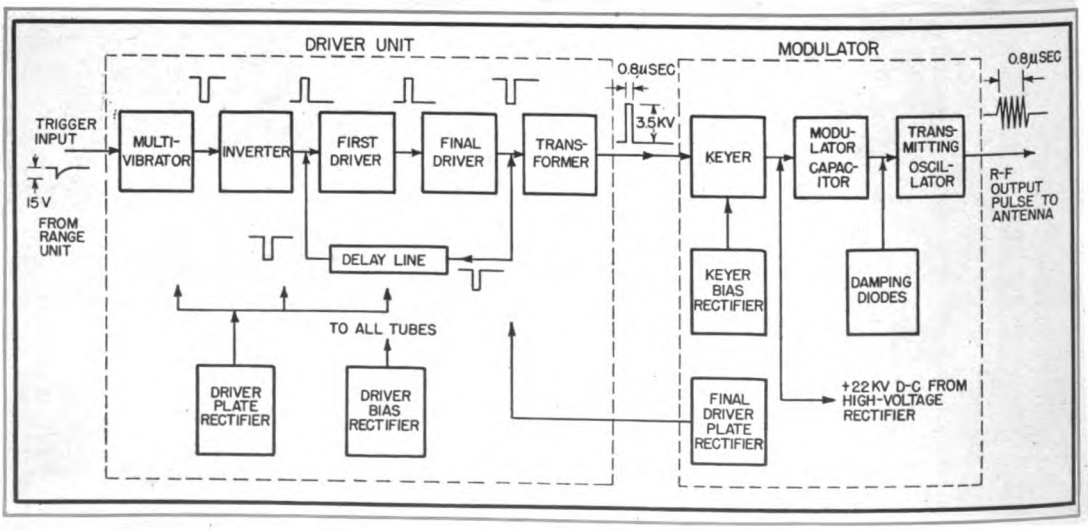

FIG. 3—Block diagram of the transmitting system. Acting under the control of the timing unit, these circuits create r-f pulses of the required length, power and rate

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back to it, thus cutting off the first driver and forming the trailing edge of the pulse. The resulting pulse appears across the output pulse transformer, with an amplitude of 3,500 volts, positive against ground.

The output of the driver is fed to the grids of the modulator or keyer tubes, two type 6C21 tubes in parallel, shown in Fig. 5. The grids are biased to −1400 volts and thus remain cut off between pulses.

When the driver pulse appears, it drives the grids of the modulator tubes into the positive region, and the modulator tubes pass a current of about 20 amperes, discharging the modulator capacitor (previously charged to 22 kilovolts) through the magnetron. This sudden passage of current excites the magnetron into oscillation at the desired frequency (in the band from 2,700 to 2,900 mc).

At the conclusion of the driver pulse, the modulator tubes suddenly become nonconducting and the discharge through the magnetron is stopped. There is a tendency for the circuit to continue to oscillate, due to resonance between the stray capacitance of the magnetron and wiring with the inductance which completes the capacitor charging circuit to ground. To damp this resonant circuit, three diodes (type 8020) are provided which conduct the positive halves of the oscillations and thus rapidly absorb the stored energy.

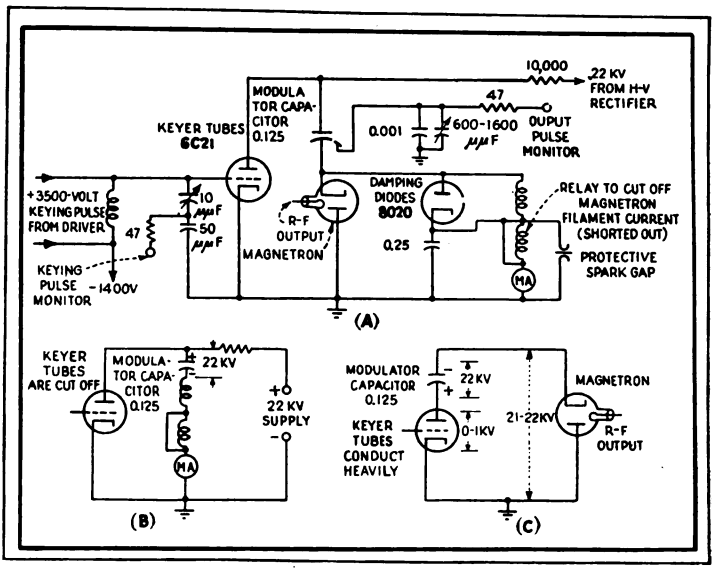

FIG. 5—(A)—Simplified schematic of the modulator and r-f generator. (B)—Equivalent circuit between pulses, while modulator capacitor is charging. (C)—Equivalent circuit during discharge through magnetron

Figure 5 shows the two equivalent circuits of the modulator. At the lower left is the condition between pulses, with the modulator tubes cut off, and the modulator capacitor charging from the power supply at a slow rate through the inductance. At the lower right is the condition during each pulse, in which the capacitor is discharged through the magnetron. The inductance, which cannot pass a sudden change in current, prevents the power supply from being short-circuited during the pulse, while allowing the capacitor to be charged at a slow rate between pulses.

The r-f transmission system, radiator, spinner mechanisms, and receiver will be described in the second article of this series.—D.G.F.

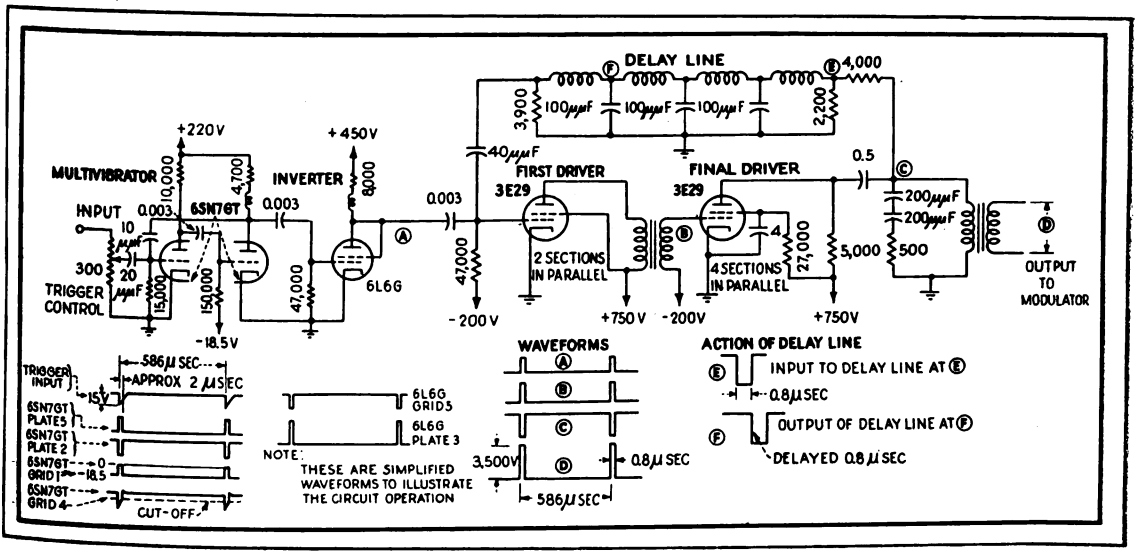

FIG. 4—Simplified schematic of the driver unit, which creates 0.8-microsecond pulses of 3500-volt amplitude for driving the modulator tubes

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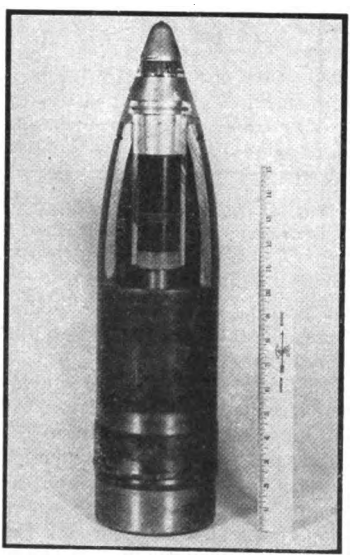
Proximity Fuze

Transmitter-receiver in nose develops a ripple signal which is used to explode projectile as it approaches target. Compact, midget construction makes possible assembly of electronic circuit and power supply in rockets, bombs and shells

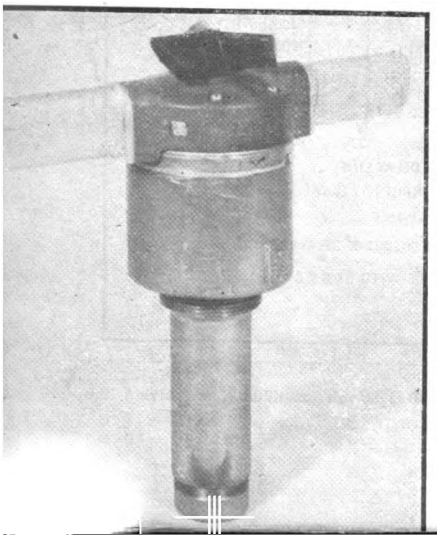
THE ELECTRONICALLY OPERATED fuze to be described causes a projectile to burst in the vicinity of its target and therefore is called a proximity or influence fuze. Under the conditions for which it was designed, a near miss is as effective as a direct hit.

The fuze, designated as a VT fuze, includes a high-frequency oscillator that excites an antenna. Depending on the strategic application of the projectile, the antenna is either the projectile itself and a small insulated metal cap, or a short, balanced dipole mounted on the nose. If radiation from this antenna is reflected back to it by a target, the apparent impedance of the antenna is changed. This change in oscillator loading is detected and fed into an electric control circuit which ignites an electrical detonator to initiate the explosion.



(Right) **Navy VT fuze for an AA shell includes a Lucite-insulated nose assembly, the electronic control circuit, a special electrolytic battery, and a triple safety assembly which arms the fuze after it has passed beyond the influence range of the gun and detonates the shell when it returns to the ground if the fuze is a dud**

(Below) **Radio-influence fuze for a bomb includes dipole antenna and wind-driven generator**



Operation

The antenna impedance as seen by the electronic fuze during flight varies in space as illustrated in Fig. 1. (The frequency at which this impedance varies, and hence the frequency that must be detected and used, depends upon the relative velocity between projectile and target.) The change in antenna impedance up to the optimum point for detonation of the projectile is a small fraction of the total impedance. Thus a circuit is required that is sensitive to loading, yet stable in operation.

If antenna impedance in free space is Z_0, and the apparent impedance in the presence of reflected waves is Z, and if the projectile is approaching the target along a path as shown in Fig. 1, the relative velocity of projectile to target is $V = V_0 \sin\theta$ where V_0 is the velocity of the projectile in a coordinate system for which the target is at rest, then

$$Z = Z_0 + Ae^{i\left(\frac{4\pi V_0 \sin\theta}{\lambda} + \phi\right)}$$

where A and ϕ are functions of the reflectivity of the target and radiation pattern of the fuze antenna.

Initial accelerations of antiaircraft projectiles, 20,000 g, and centrifugal forces produced by rotation at 475 rpm, necessitated development of rugged tubes and circuit components. The initial acceleration and acquired centrifugal force are used to break a vial of electrolyte and diffuse it throughout the specially developed battery used for power in fuzes for this class of missile. By this method the fuzes are held inactive until the instant of gun firing, and deterioration of batteries is prevented.

Bombs and rockets are launched at high altitudes after being carried aloft and cooling to as low as — 60 C, thus batteries are unreliable for power in this type of missile. Miniature, high-speed, wind-driven generators were developed. The use of these generators also simplified safety measures because, unless the missiles are in motion, there is no power.

Vibrations from the missile and generator required tubes that were free from microphonics.

Strategic Uses

Success of airplanes against surface ships in the early stages of the war indicated a need for more effective weapons. Radar provides advance warning and gun direction against aircraft, but the necessity of accurately measuring target

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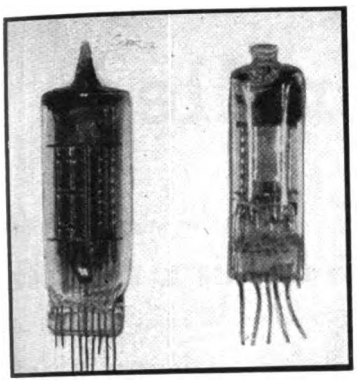


Typical tubes used in VT fuzes are similar to hearing-aid tubes. Types include triode, pentode and thyratron

range and setting time fuzes limited effectiveness of fire. A fuze was needed that would increase effectiveness of attack on airborne targets by shells from ship or ground AA or by rockets from fighter aircraft, and on ground targets by howitzer shells or bombs.

When a VT-fuzed projectile is used against an airplane, the fuze detonates the shell when its fragmentation will embrace the target as shown in Fig. 2, even if its path would not result in a direct hit as is necessary for contact-fuze detonated missiles, or if range has been inaccurately determined in the case of time fuzes.

When a VT-fuzed bomb, artillery or mortar shell is used against partially shielded personnel and light equipment, its effectiveness is greatly increased through its ability to shower high velocity fragments into the fox hole or revetment.

Against Jap kamikaze bombers, Nazi buzz bombs, and in the Battle of the Bulge, the proximity fuze was highly praised by tactical personnel. In such Pacific Island operations as Iwo Jima and Okinawa the fuze was used by us during attack to disrupt enemy gun operation through bombing and later during defense to shoot down enemy aircraft by VT-fuzed AA.

Development

The National Defense Research Committee centered research on influence fuzes for the Army and Navy at Carnegie Institution of Washington in mid 1940. The project was soon divided into two parts.

Development of fuzes for non-rotating projectiles such as rockets, bombs, and mortars was conducted through the Bureau of Standards under NDRC and Army Ordnance; fuzes for rotating projectiles including field artillery and antiaircraft projectiles were developed through Carnegie Institution and Johns Hopkins University, this portion of the project being transferred to the OSRD and later to the Navy Bureau of Ordnance.

Special tubes and components were developed in cooperation with numerous manufacturers. One-third of the electronic industry in the United States was involved. Manufacturing capacity for tubes, capacitors, and resistors was tremendously increased. Cost of the project approached a billion dollars; over 20 million expendable fuzes were produced, and upward of 100,000 individuals were directly involved in development and production.

As a new weapon the VT fuze combined increased destructiveness and surprise. On the home front the project was shrouded in secrecy, the industries working in cooperation with war agencies not even receiving well-merited E awards so that talk about the fuze would be held to a minimum. Armed guards accompanied all fuze shipments.

In battle the proximity fuze was used at first in areas where duds could not land in enemy territory. In this way the maximum element of surprise was obtained. Its development rates as one of the best kept of war secrets, and is a monument to scientific and engineering skill, industrial productivity, and official coordination.

British scientists were working on influence fuzes for rockets and bombs in 1939. Later, their efforts were combined with ours. German scientists, although they had begun research on proximity fuzes in the early 1930's, did not develop usable models because of lack of coordination and duplicity of effort.

Material and assistance for the preparation of this article were generously supplied by H. Diamond, Dr. R. D. Huntoon, Dr. C. Brunetti, Dr. J. A. Hynek, and Mrs. D. Schulte. Col. C. H. M. Roberts read the first draft and made valuable suggestions as to the proper nomenclature.—F.R.

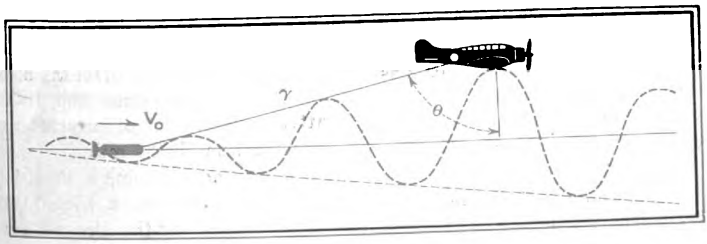
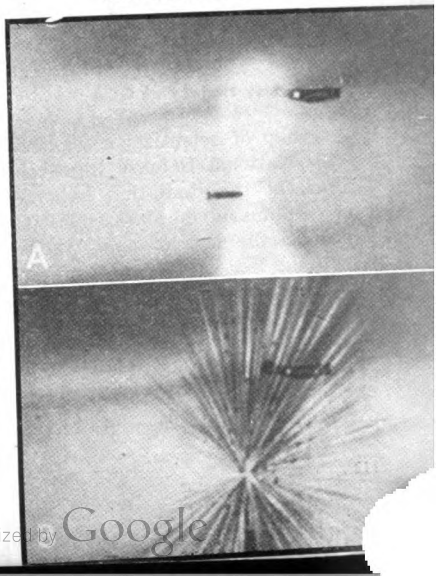


FIG. 1—*(left)* Interference pattern established at moving projectile antenna by Doppler effect varies as target is approached, resulting in fluctuation in antenna impedance as shown by dotted curve

FIG. 2—*(below)* (A) Although this rocket will not directly hit the airplane, its radiation field, shown in white, does. (B) The shell is detonated within damaging distance of the target



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Ground-Controlled

GCA equipment ready for use at an Army Airways Communications System airfield. The radar antennas are atop the trailer, along with conventional whip antennas for radio communication with incoming aircraft

By CAPTAIN C. W. WATSON

Radar Officer
Headquarters, Army Airways
Communications System

ONE of the last radar developments of the war may turn out to be the most important for peacetime aviation. Aircraft arrivals and departures may soon be scheduled to and from airports without regard to the weather, an accomplishment made possible by an Army-Navy electronic device that has been used since early this year to land aircraft during weather conditions nearing zero ceiling and visibility. The radar system which makes closed-in airports a thing of the past is known as Ground Controlled Approach (GCA), and is the result of four years of experimentation and testing.

Early History of GCA

A group of scientists assembled by the National Defense Research Council at the Radiation Laboratories, Cambridge, Massachusetts, conceived the idea of using radar for blind landings of aircraft in 1941 and the process of development was begun. The first model, known as Mark I, was finished in 1943, after being assembled from existing airborne radar sets then available. The unit was flight tested in the U. S. and in the British Isles, where it convinced those engaged in the development that it was operationally sound.

Although it demonstrated the potentialities of GCA, the Mark I version was not quite what the Radiation Laboratory scientists wanted. The succeeding model, Mark II, included many refinements. It was, however, outmoded before production was thoroughly underway and the result was the emergence of the Mark III model which is the GCA in use today.

Justification for the development of an electronic device of this type was not long appearing. Rushed to the European and Pacific theaters early this year, it quickly demonstrated that planes could be brought down through zero-zero weather safely and efficiently. Operated by personnel of the Army Airways Communications System for the U. S. Army Air Forces, GCA made regular flight schedules possible around the clock when our airfields were completely closed in by fog. At Iwo Jima alone, in the final phases of the war against the Japanese, it saved scores of superforts and nightfighters returning from missions at a time when Maple airfield on Iwo Jima was invisible at a distance of one hundred feet.

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Two Radars Are Used

GCA is a completely self-contained mobile radio set having two ground radar systems together with the necessary communications facilities. One of the radar systems, known as the search system, operates on a shf band and is designed to aid in or control the homing, holding, stacking and traffic pattern operations of aircraft out to approximately 30 miles.

The second system, a precision system, operates on a higher shf band and controls the aircraft during its actual let-down along a predetermined glide path. The unique characteristic of this type of radar-controlled approach is that no special equipment is required in the aircraft other than ordinary air-ground communications equipment.

Search Radar Characteristics

The search radar system provides the GCA operators with information on the azimuth bearing and range of aircraft from the airfield at distances up to 30 miles and at altitudes up to 4,000 feet. To ac-

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Approach for Aircraft

In GCA, two microwave radar systems at an airfield reveal the exact position of an incoming aircraft with respect to the landing glide path, permitting the ground operator to radio precise flight instructions to a pilot coming in through zero-zero fog. Possibilities for around-the-clock traffic control and landing at commercial airfields are promising

complish this purpose, the search antenna used with the search radar system is designed with a number of horizontal dipoles in a vertical linear array. Such an arrangement gives coverage as in Fig. 1A.

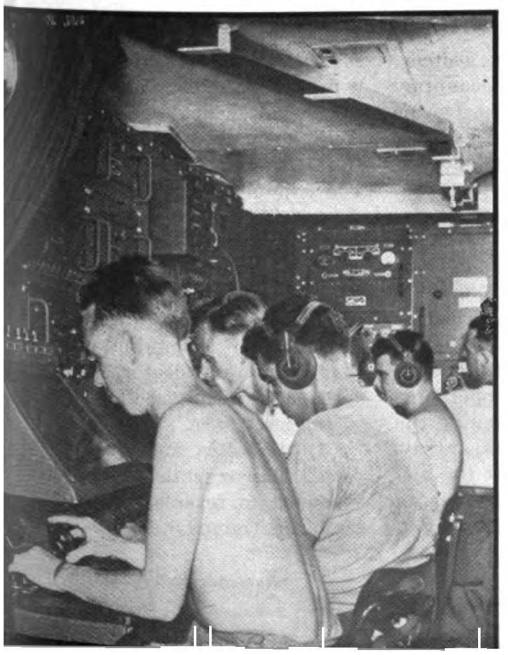
The search antenna system examines the space around the GCA set by an actual rotation of the antenna and its reflector, the rotation of the visually displayed indicator sweep being synchronized with the antenna. The antenna beam is approximately six degrees wide in azimuth. (Its relation to the plan-position indicator from which the operator obtains his display of information is shown in Fig. 1B and 1C.) The narrow beam width needed is obtained by placing a parabolic reflector behind the antenna array to focus the beam.

Since the speed of antenna rotation is very slow in comparison to the time that it takes a pulse of energy to travel from the antenna to an object (186,000 miles per second) and be reflected, the energy gets back before the antenna has moved appreciably. The transmitting antenna can thus be used also as a receiving antenna simply by connecting the antenna as a radiator for the period of pulse radiation, then switching the antenna to the receiver input and leaving it thus connected until the energy pulse has had sufficient time to travel out 30 miles (161 microseconds) and back (another 161 microseconds). The cycle is then repeated. Energy pulses are of 0.5 microsecond duration and occur at the rate of 2,000 per second, so that there are 500 microseconds between pulses. This is sufficient time for a pulse to travel out 30 miles and back; specifically, the pulse consumes 322 microseconds of the 500 microseconds made available.

Magnetron Generates SHF Power

The transmitter is built around the cavity magnetron oscillator tube. This tube provides enough power output, at the frequencies required, so that sufficient energy is available for indications at the receiver after the pulse of energy has traveled 30 miles, has been partially reflected from an object, and the reflection returned to the re-

Inside the trailer, these men watch the PPI search pattern and the expanded precision indicator patterns on cathode-ray tube screens, and adjust control knobs that transfer position indications to the radio operator



All position indications go to one man, who brings an aircraft in to a safe landing through fog by voice instructions alone. Experience has shown that pilots respond even faster to voice instructions from the ground than to instruments they might be watching

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ceiver. This performance may not appear remarkable until one realizes that radiated energy decreases inversely as the distance squared, which means that at 80 miles there is only 1/900th of the power available at one mile. Also, objects vary in reflection qualities, and no object reflects back more than minute portions of the total energy received. This small amount of energy is then subject to the same decrease in strength on its return path as on its radiation.

The requirements for pulse power output and receiver sensitivity are far beyond any provided in commercial designs of radio receivers and transmitters made to date. The magnetron, however, provides r-f oscillations modulated by a pulse of approximately 10 to 15 kilovolts and 0.5 microsecond in duration, and by beaming this energy to the 6 degrees mentioned previously, enough energy is reflected from an object to provide the concentration desired.

Plan-Position Indicator

By means of a transmit-receive switch the antenna is alternately connected to the receiver and transmitter at a switching rate of 2,000 times per second. The echo pulses received by the antenna are fed through amplifying stages and displayed on the plan-position indicator. This is a high-persistence cathode-ray tube that displays at its center the transmitted pulse, and has an illuminated line from the center of the tube to its outer edge to display the azimuth of search while the receiver is switched into the antenna circuit. The line rotates with the tube center as its hub, but it is actually a stream of electrons which starts at the tube center, runs out to the edge, and then returns to repeat the same procedure at the rate of 2,000 times a second. This fact, plus the persistence of the tube face, make the radial line appear continuous. Echoes show as brightened blobs of light.

The heart of the complete search system is the synchronizer which furnishes the modulator, transmitter, receiver, and indicators with starting and stopping signals.

Traffic Control

Operators of the search system merely watch for targets on the indicator and, by using the air-ground communications equipment provided, vector the aircraft to the range and bearing desired. This type of information is necessary for efficient control of aircraft approaching a field for a landing under instrument conditions.

By means of the GCA search system, aircraft can be held at a given point and stacked in altitude prior to landing. It serves to line up the aircraft in azimuth with the precision radar system where the actual let-down of the aircraft is begun.

Precision Radar System

The precision radar system is designed to provide operators with accurate information on azimuth headings, altitude, and range up to 10 miles. For the more precise close-in work a two-mile indication is also provided. The area of coverage by the precision antennas is 20 degrees wide in azimuth (15 degrees to the left of a line from the set parallel to the runway and 5 degrees to the right) and 7 degrees high in elevation (6 degrees above the ground level and 1 degree below). The coverage areas are shown in Fig. 1D and 1E.

Antennas for Precision Scanning

Two separate antenna systems are used in precision scanning. One, the elevation antenna, sweeps an area 3 degrees wide in azimuth and 7 degrees in elevation; the other, the azimuth antenna, sweeps an area 1.5 degrees in elevation and 20 degrees wide in azimuth. Actual beam dimensions for the azimuth antenna are 1.5 degrees in height and 0.6 degree in width. The sweeping of the 20-degree azimuth area is accomplished electrically by proper time phasing of the energy feeding the dipoles in the horizontal array. The beam dimensions for the elevation antenna are 3 degrees in width and 0.4 degree in height. The sweeping of the 7-degree elevation area is also accomplished electrically, by proper phasing of the energy feeding the dipoles in the vertical array.

The cross-hatched rectangular area shown in Fig. 1D is the area covered by both antennas as their beams are swept in elevation and azimuth. The proper time phasing of the energy feeding the dipoles for both the horizontal and vertical array is made possible by squeezing and expanding the waveguide transmission line which feeds the antennas. Both antennas are equipped with reflectors that focus the radiation of pulse energy.

Antenna Switching Sequence

As in the search system, the precision transmitting antennas are also used for receiving the reflected energy. The elevation and azimuth antennas alternately are switched from receive to transmit, the switching rate being high in comparison to the squeezing of the waveguide which carries the beam through the sweep sector. Thus, the cycle can be explained as follows:

(1) *Elevation antenna energized.* The waveguide is squeezed by means of a cam which lifts the elevation beam from minus 1 degree to plus 6 degrees. At this point, the elevation antenna becomes deenergized through the action of an r-f switch and the cam leaves the elevation beam in its raised position.

(2) *Azimuth antenna energized.* The waveguide feeding this antenna is also squeezed by a cam arrangement, which sweeps the azimuth beam from plus 15 degrees (left) to minus 5 degrees (right). The azimuth antenna then is deenergized and the cam leaves the azimuth antenna in its extreme right position.

(3) *Elevation antenna deenergized.* The elevation wave guide is expanded to lower the elevation beam to minus 1 degree, where the antenna is deenergized and left until the next cycle.

(4) *Azimuth antenna deenergized.* The azimuth wave guide is expanded to reverse the sweep of the beam (minus 5 degrees to plus

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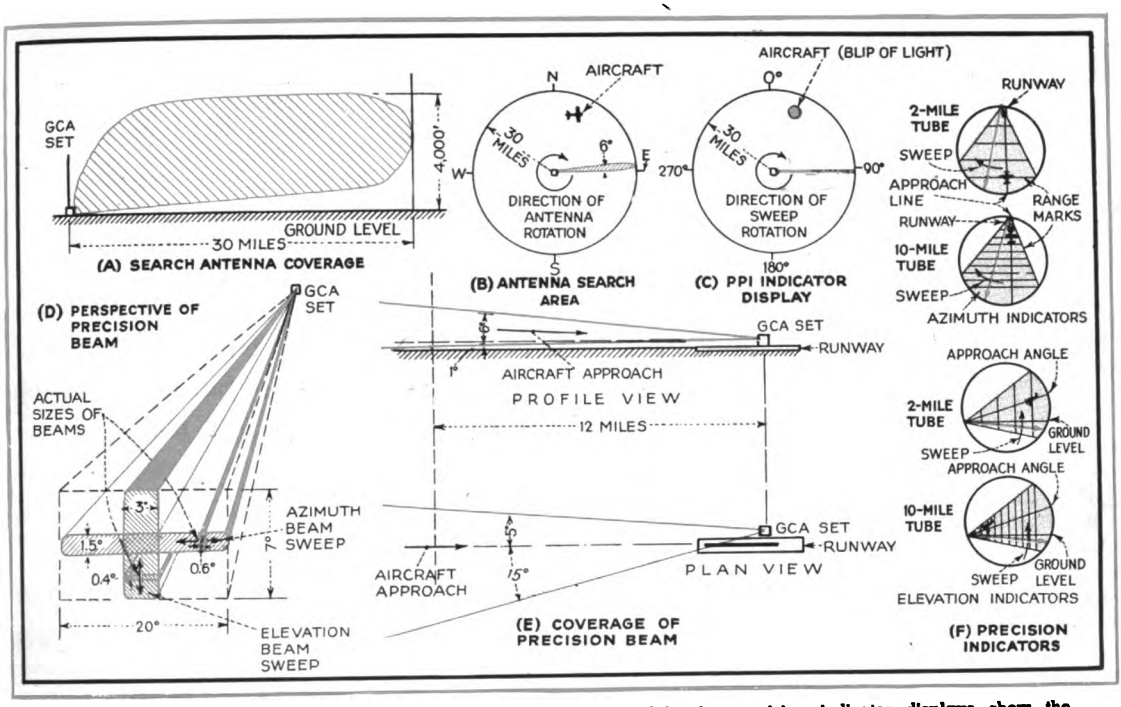

FIG. 1—Characteristics of microwave beams used in GCA, and types of patterns obtained on the scopes. The PPI indicator display shows positions of all aircraft within 30 miles, while the precision indicator displays show the relation of the aircraft to the correct landing path in both horizontal (azimuth) and vertical (elevation) directions

15 degrees), where the antenna is deenergized and left until the next cycle.

Shifting of Precision Beams

By using the above process, the system requires only one magnetron tube, which is pulsed at a much higher rate than it takes to complete a half of the above cycle. To achieve accurate resolution of signals this magnetron oscillates in the shf band. Together with the beam width obtained, it provides an accuracy of approximately five feet within one mile range. In this manner, the area of the elevation beam (3 degrees wide and 7 degrees high) and the azimuth beam (1.5 degrees high and 20 degrees wide) is receiving a high concentration of radar pulses. The elevation beam can be shifted in azimuth to locate aircraft and the azimuth beam moved in elevation to locate any aircraft within the area 7 degrees high by 20 degrees wide. This shifting is done mechanically by servo-mechanisms connecting the antennas and the indicators so that the operators may direct the beam sweeps to the proper point of contact.

Indicator Displays

Since the major components of the search and precision system are identical in function, the only major difference to be explained is the method of display of information on the cathode-ray tubes. Both azimuth and elevation information is provided on the indicators, together with ranges.

A main feature of this development is the expanded partial-indication display used. Each tube has the sweep center not in the middle but on the outer extremity of the tube face, with the sector (20 degrees wide on the azimuth tube and 7 degrees high on the elevation tube) expanded across the tube. The sweep applied to the indicators is synchronized with the sweeping of the precision antennas. Upon completion of the sweep cycle of the antennas the proper indicator sweep line is blanked out electrically until the cycle is reversed and starts again. The coverage area provided on the indicators is illustrated in Fig. 1F.

By means of tracking cursors following the aircraft blip, electrical meters record the azimuth error in degrees and the elevation deviation in feet with respect to the correct approach line and angle. This information is then relayed over the communication system to the pilot and the proper corrections made in heading and rate of descent.

Summary

The search and precision radar systems, the air-ground communications facilities, and the selective intercommunications system between operators enable the GCA controller to give positive, accurate data on an aircraft's range and bearing from the airfield. In addition, the pilot is given altitude, range, and bearing information in the last ten miles of the approach which enables him to bring the aircraft to a point where a visual landing can be made.

The Army and Navy in less than one year of operation of this electronic system have saved many planes that would otherwise have been ditched. GCA will no doubt be improved by further research and development. It promises to eliminate that ultimate danger to flying, inability to land at the airport of destination.

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Radar Specifications

The significance of new technical terms and constants, used to specify the performance of a radar, is outlined and illustrated by an extensive tabulation of Signal Corps equipment employing carrier frequencies from 110 to 10,000 mc

NOW THAT TECHNICAL DETAILS of radar equipment are being released, engineers not previously familiar with the art find themselves confronted with a bewildering array of new terms and constants, knowledge of which is essential in estimating and comparing the virtues of different equipments. It is the purpose of this survey to explain these new technical specifications.

Basically, radar specifications relate to the performance of the gear, that is, the maximum distance at which a given target may be detected, and the accuracy and continuity with which its position may be specified. The maximum distance is determined primarily by the pulse specifications and receiver sensitivity. The accuracy of position is determined by the angular width of the radiated beam and the precision of timing of the radar echo. The continuity of following the target depends on the number of contacts per minute between radiated beam and target. Each of these relationships is discussed in the following paragraphs.

Pulse Specifications

Among the constants which determine the maximum distance at which a radar can detect a target are the pulse specifications, that is, the carrier frequency, peak power, and duration (width) of the transmitted pulses. These quantities are contained in the radar equation, which specifies the maximum range of detection in terms of equipment constants. This equation has already been derived in these pages[1], to which the reader is referred for a detailed statement of underlying principles. The form of the equation pertinent to this discussion is

$$r_{max} = \sqrt[4]{\frac{P_t A^2 \rho d}{nkT\, 4\pi\lambda^2}} \text{ meters} \qquad (1)$$

Here r_{max} is the maximum distance, in free space, at which a target of area ρ square meters can be seen. The pulse specifications are the peak power P_t in watts, the pulse width d in seconds, and the operating wavelength λ in meters. The other factors of interest are the area A in square meters of the reflector which forms the radiated beam, and the noise figure of the receiver n, expressed as a ratio relative to the minimum theoretical noise, $kt\Delta f$, where Δf is the bandwidth of the receiver in cps. The constants kT are equal, at room temperature, to 4×10^{-21} watts per cycle of bandwidth. Using Eq. 1 it is possible to predict the range performance of a radar if the pulse specifications, as well as the reflector area and receiver noise figure, are known. The maximum range depends, of course, on the area of the target ρ. For a medium bomber this figure is approximately 50 square meters.

Two other aspects of the pulse are of interest. First, the pulse width represents the time during which the receiver cannot receive echoes because it is blocked by the transmitter. Consequently echoes from nearby targets, arriving while the transmitted pulse is still leaving the radiator, cannot be perceived. The pulse width thus sets a lower limit to the minimum range of detection. Other factors, particularly recovery of the receiver circuits, may prolong the inactive time beyond this lower limit.

At the other end of the scale, the pulse rate determines the maximum detection range. This follows since the interval between pulses, during which echoes may be perceived, is the inverse of the pulse rate. Thus the lower the pulse rate, the longer the interval and the greater the distance at which targets may be perceived, within the limits of the transmitter power and receiver sensitivity. If a high pulse rate is used, distant targets may still be perceived, but the echoes may arrive not in the first interval between pulses but in some later interval. In this event an ambiguity exists, since one cannot be certain whether the echo interval is that shown on the indicator, or longer by some multiple of the pulse interval. In general, radars intended for long-distance detection employ low pulse rates.

Radiator Specifications

The precision of detecting the position of the target in azimuth (horizontal angle) and elevation (vertical angle) rests fundamentally on the size of the radiated beam. The larger the reflector and the shorter the wavelength, the narrower the beam and the higher the angular precision. The angular width of the beam is

$$b = \frac{\lambda}{\sqrt{4A/\pi}} \text{ radians} \qquad (2)$$

where A is the area of the reflector

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in square meters and λ is the operating wavelength in meters.

It is evident that the beam width is intimately tied up with the factors A and λ which have previously appeared in the equation for maximum range. This is true because as the beam becomes smaller, the energy density in the beam increases for a given transmitter power, and hence the range increases. This effect is often stated in terms of the radiator gain, that is, the ratio of the energy density actually present along the axis of the beam to the energy density which would be produced by the same power feeding an isotropic (broadcast) radiator. The equation for gain is

$$G_0 = \frac{4\pi A}{\lambda^2} = \pi^2/b^2 \qquad (3)$$

where A, λ and b are as previously defined.

In most cases it is possible to determine the angle to the target to a small fraction (say ½ to 1/10) of the beam width. When conical scanning (described in the article on the SCR-584, beginning on page 104 of this issue), the angular accuracy can be refined to a few hundredths of the beam width.

The accuracy of timing the radar echoes, which determines the precision of the range coordinate, depends on many factors in the timer and indicator design, so it is generally stated as an overall performance figure. Outstanding in this respect is the performance of the SCR-545 and SCR-584, both of which can determine range accurately to plus or minus 15 yards. This is equivalent to a timing accuracy of the order of 0.06 microsecond. This high performance is required in a radar intended to control gun-fire, since it permits the fuze of the shell to be set to cause it to explode at the target. In early warning radars, and those used to control searchlights, such precision is not required. Thus the SCR-270 early warning radar has an accuracy of 8000 yards, and the AN/TPL-1 searchlight set an accuracy of 200 yards.

Scanning Specifications

Continuity in following the target depends on the scanning constants of the radar, that is, the rates at which the radiated beam is moved in space in searching for and following the target. Two aspects of scanning are of interest:

the number of pulses radiated while the beam moves over the target, and the number of contacts per minute between beam and target.

The first aspect is simply analyzed. Consider a beam of angular width b radians, scanning at an angular rate of r beam widths per second. Then the beam moves through an angle equal to its own width in b/r seconds. In that time at least one, and preferably five or more pulses, must be radiated. If less than one pulse is radiated in that time, a point in space may be moved over without a pulse hitting it, and a target at that point will remain undetected. If five or more pulses are radiated in that time, several pulses will hit the target and the effect of the echo, integrated on the cathode-ray screen, will be sufficient to cause full screen brilliance. It follows that the pulses must be radiated at a rate of $5r/b$ per second, or at a higher rate, if each point in the scanned space is to receive sufficient pulses to cause a clearly discernible echo. In equation form

$$f_r \geq 5r/b \qquad (4)$$

It is evident that the higher the rate of scanning and the narrower the beam width, the higher must be the pulse rate. As a numerical example, consider the wide-beam slow-scanning SCR-270 early warning radar, which has a beam width of 28 degrees in azimuth and scans in azimuth at 1 rpm or 360/60 = 6 degrees per second. The 28-degree beam thus moves through its own width in about five seconds. The pulse rate is 621 per second, so in five seconds some 3100 pulses are radiated, and each point in the scanned space receives this large number of pulses.

In contrast, consider the AN/MPG-1, a narrow beam, rapid-scanning set. This radar scans in azimuth at a rate of 160° per second with a beam width in azimuth of 0.6 degrees. The scanning thus occurs at a rate of about 0.004 seconds per beam width. The pulse rate while tracking is 4098 per second, so 0.004 × 4098 = 16 pulses are radiated while the beam passes through its own width. This number is in excess of the minimum value (five pulses) previously stated. When the lower pulse rate (used for searching) of 1024 pulses per second is used, only four pulses are radiated and this is somewhat below at the lower limit.

The other aspect of scanning is frequent contact between beam and target. When a target is detected and attention can be restricted to it alone, it is possible to suspend the search and concentrate on the particular target in question. But in early warning activities it is necessary to maintain a watch on several targets simultaneously, and to anticipate the appearance of new targets at all times. In such cases search cannot be suspended, and continuity of following the target then depends on frequently recurring contacts with the target. The SCR-270 scans the horizon at one rpm, and the target information is thus renewed once every minute. The persistence of the cathode-ray screen is employed to store the information over the one-minute interval so the motion of the target can be followed from one scan to the next. But if the target is close,

MORE TO COME

The specifications presented here are those of ground-based sets employed for the most part by the Army Ground Forces for detection of marine and aircraft targets and gunfire control.

Airborne and shipborne radars have not yet been declassified. Similar information on them will be presented as soon as it is available

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or moving fast, it cannot be followed from one scan to the next if a minute of time intervenes. For following nearby fast-moving targets, the beam must rotate at a faster rate. The SCR-584 used for antiaircraft fire, scans the horizon at six rpm, making contact with the target six times as often as the SCR-270. The AN/MPG-1 scans a 10-degree sector in 0.0625 second, giving substantially continuous coverage.

When it is necessary to use a narrow beam (for precision) and to search in elevation as well as in azimuth for targets, the simple circular scan just described must be expanded into a helical scan. In helical scanning the beam rotates horizontally, as previously described, but superimposed on the horizontal motion is a vertical tilt at a slow rate, which causes a point on the radar beam to describe a helix. The angular distance between the turns of the helix is less than the beam width, so that all points in space are covered during the scan. The same requirement governs the pulse rate as in circular scanning, namely at least five pulses must be radiated while the beam rotates through its own width. When helical scanning is employed, the contacts with the target are cut down by approximately the number of turns in the helix, relative to those made in circular scanning at the same azimuth rate. If continuous contact with the target is required under those conditions, the azimuth scanning rate must be increased, to cover many turns of the helix in a brief time. The limit in the azimuth rate is generally set by the strength of the scanning mount, which may jam or shatter due to unbalance stresses if rotated at too high a speed.

Indicator Types

The tabulation lists the types of indicators used. Type A refers to a presentation very similar to that of a test oscilloscope, in which the c-r spot moves horizontally at constant speed, measuring the echo interval, and is deflected vertically by the transmitted pulse and the

TECHNICAL SPECIFICATIONS OF REPRESENTATIVE SI

Type Number	SCR-268	SCR-516	SCR-270	AN/TPS-3	SCR-545
Primary Function	Searchlight and gun control (mobile)	Early warning against aircraft (mobile)	Early warning against aircraft (mobile)	Light weight for search and tracking (mobile)	Search (s) and track (t) for AA fire-control (mobile)
Size, Weight	Two trailers; 28,850 lb	Same as SCR-268	3 trucks and trailer; 81,400 lb	Air-transportable; 1340 lb	2 trucks and trailer; 71,460 lb
Carrier Frequency (mc)	195-215	205	110	600	205 (s) 3000 (t)
Wavelength (λ) (cm)	140-154	146	270	50	146 (s) 10 (t)
Peak Power (P_t) (kw)	50-75	100	100-300	200	200 (s) 350 (t)
Pulse Width (d) (microseconds)	5-9	5-8	10-30	1.5	1
Pulse Rate (f_r) (pps)	4098	1366	621	200	480
Radiator Type, Size, Gain (G_o)	Three mattresses; 100	Same as SCR-268	4x9 mattress; 140	10-ft paraboloid; 220	4x4 mattress (s) 60; 57-in. parab. (t) 1300
Types of Scan	Manual track in azimuth and elev.	Manual search	Circular search	Circular search	Helical search, conical track
Beam Width (b) (degrees)	12 az., 9 el.	12 az., 9 el.	28 az., 10 el.	12.5 az., 11.5 el.	25 (s), 5 (t)
Horizontal Scanning Rate (rpm)	Manual	Manual	1	6	5
Receiver Noise (n) (db above $kt\Delta f$)	14	14	12	11	7 (s), 22 (t)
Receiver Bandwidth (Δf) (mc)	1.5	1.5	1.5	1.8	1.25 (s), 5 (t)
Indicators	3 type-A	3 type-A	1 type-A	1 type-A, 1 type-PPI	3 type-A
Maximum Range (r_{max}) on Bombers at 10,000 Feet (miles)	23	68	80-120	100	34 (s), 16 (t)
Minimum Range (yd)	3000	3000	10,000	10,000	1100 (s), 500 (t)
Range Accuracy (yd)	200	500	8000	4000	150 (s), 15 (t)
Angular Accuracy (degrees)	1.1	3	4	2	6 (s), 0.17 (t)

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echo. The time between the two is a measure of the range. Type J is similar, except that the trace is circular, about the periphery of the tube, rather than linear. Type PPI has been described elsewhere in this and previous issues; it produces a map-like indication by radial deflection from the center of the tube, the deflection keeping step with the azimuth rotation of the radiated beam. Type B presents range information vertically and azimuth information horizontally, in rectangular coordinates, and is thus a distorted portion of a PPI picture. Tube sizes vary from 3-inch (SCR-584 J-scopes) to 12-inch (SCR-270 PPI). Most A-scopes are five-inch tubes and PPI's are typically about seven inches in diameter.

The sets described here cover the gamut of radio frequency from 110 mc to 10,000 mc (270 centimeters to 3 centimeters wavelength). The peak power employed varies from 50 to 350 kw. These are typical figures, although higher powers have been used in early-warning sets employed by the Air Forces and the Navy. In general, the beam widths, pulse rates and scanning rates will be found consistent with the requirements previously stated. Moreover, the maximum ranges quoted are generally consistent with the radar equation, when the indicated constants are substituted. One major difference should be stated, however. Some of the maximum ranges given are those which occur when the radar beam is partly reflected from the surface (sea or ground) and partly transmitted directly to the target. Constructive interference of the two waves may, in ideal circumstances, double the maximum range predicted by the radar equation. Destructive interference, under the same circumstances, may similarly reduce the maximum range to zero miles. Hence a wide variety of possible maximum ranges exists, depending on the conditions of measurement. The radar equation gives an index to average performance.—D.G.F.

REFERENCE

(1) Fink, D. G., The Radar Equation, ELECTRONICS, p 92, Apr. 1945.

U.S. SIGNAL CORPS RADARS

SCR-547	SCR-582/682	SCR-584/784	AN/TPL-1	AN/MPG-1	Type Number
Range finder for AA fire-control (mobile)	Coastal search for ships and planes (fixed)	Search (s) and automatic track (t) for AA fire-control (mobile)	Light weight searchlight control (mobile)	Seacoast fire-control against marine targets (mobile)	Primary Function
2 trucks and trailer; 49,487 lb	3359 lb (582); 13,640 lb (682)	Trailer, 20,000 lb (584); 12,000 lb (784)	Trailer; 4205 lb	Trailer; 28,000 lb	Size, Weight
2720-2890	2800	2700-2900	2700-2900	10,000	Carrier Frequency (mc)
10	10.7	10-11	10-11	3	Wavelength (λ) (cm)
80	30 (582) 225 (682)	300	200	60	Peak Power (P_t) (kw)
0.5	1	0.8	1	1 (s) 0.25 (t)	Pulse Width (d) (microseconds)
4098	500 (582) 420 (682)	1707	400	1024 (s) 4098 (t)	Pulse Rate (f_r) (pps)
2 57-inch parab.; 5000	4-ft paraboloid; 800-900	6-ft paraboloid; offset dipole; 1200	4-ft paraboloid; 860	Schwarzchild rapid-scanner; 12,000	Radiator Type, Size, Gain (G_o)
Range only, optical tracking	Circular search	Helical search, conical track	Helical search, conical track	Circular search; also 10° sector; track	Types of Scan
3.8	6	4 (7 when spinning)	10	0.6 az., 3 el.	Beam Width (b) (degrees)
Manual	10-20	6	7.25	160°/sec	Horizontal Scanning Rate (rpm)
—	18 (582), 14 (682)	15	18.5	17	Receiver Noise (n) (db above $kt\Delta f$)
6	1.5 (582), 2 (682)	1.7	1.8	10	Receiver Bandwidth (Δf) (mc)
1 type-A	1 type-A, 1 type-PPI	2 type-J, 1 type-PPI	3 type-A, 1 type-PPI	2 type-B, 1 type-PPI	Indicators
12	45 (582), 140 (682)	34 (s), 18 (t)	34	28 (battleship)	Maximum Range (r_{max}) on Bombers at 10,000 Feet (miles)
300	1000 (582), 500 (682)	500	500	—	Minimum Range (yd)
25	2 per cent	15	200	—	Range Accuracy (yd)
—	2	1 (s), 0.06 (t)	1 (s), 0.5 (t)	—	Angular Accuracy (degrees)

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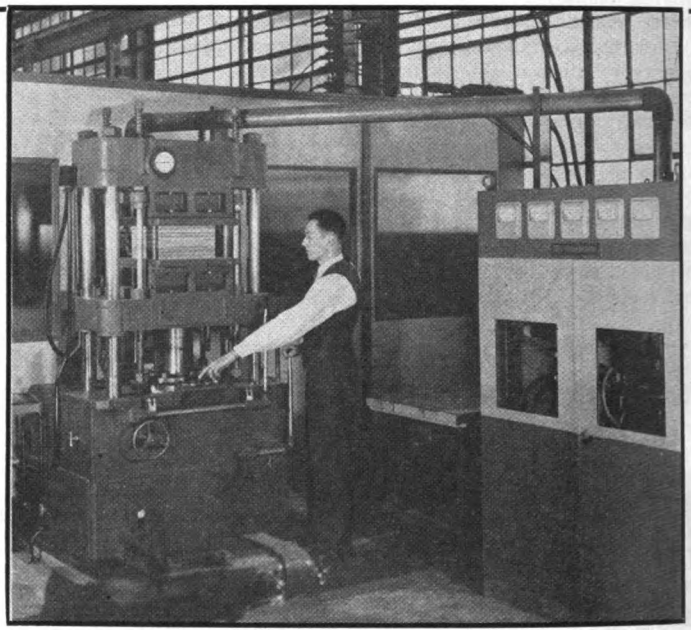
Dielectric HEATING

By DOUGLAS VENABLE

Industrial Electronics Division
Westinghouse Electric Corp.
Baltimore, Md.



The r-f generator at the right supplies heat energy for bonding plywood in the press, a typical application of dielectric-heating equipment

DIELECTRIC HEATING is today opening many new fields in industry, and speeding up many old processes. Materials such as rayon, wood, foods, and plastics are being dried; plastics and rubber are being cured; wood and plastics are being bonded one to another and to metals. Greater production rates have been attained in the molding or forming of plastic preforms. Even some cooking of foods is being done.

To best make use of high-frequency power for industrial heating applications, it is necessary that the manufacturer and producer of dielectric materials, who may use or contemplate using high-frequency power, have an understanding of the fundamentals of dielectric heating.

Molecular Dipoles

If one were to examine, by some microscopic means, the molecules of a dielectric which are immersed in an electrodynamic field, he might well appreciate the generation of heat within the dielectric. At some time when the electric field is zero, a molecule might be seen to have its center of postive charges and its center of negative charges coincident, or he may see these centers displaced a given distance relative one center to the other. This latter molecule is called a permanent molecular dipole.

The orientation of the permanent molecular dipole would necessarily be a function of the properties of the molecule of the dielectric as well as the history of the molecule. The individual positive and negative charges are being held in place by very appreciable forces so that their resultant centers are coincident or permanently displaced (assuming zero external electric field), even though the electrons of the molecule are very active. As the electric field changes, these centers of positive and negative charges might be seen to be displaced relative one to another forming induced dipoles whose axes are parallel to the electric field.

Power Density

The permanent dipoles will be influenced by a torque tending to rotate them until their axes are parallel to the electric field. An added displacement may also take place between the electrical centers of the permanent dipoles. In so displacing the centers and/or causing a rotation of permanent dipoles, work is done, for work is simply defined as the overcoming of resistance through distance.

Since power is the time rate of doing work, the power absorbed by a dielectric from an electrodynamic field in which the dielectric is immersed is some function of the time rate of change of the electric field. Thus, the energy absorbed per unit time may be considered a function of frequency. Heat power generated within a dielectric because of hysteresis may be thought of as the time rate of energy required to produce molecular deformation and rotation.

It may be shown for practical purposes that

$$P_o = 1.4 f E_1^2 \epsilon'' \text{ watts per cu in.} \quad (1)$$

where f = Frequency in megacycles
E_1 = Voltage gradient in kilovolts rms per inch
ϵ'' = Loss factor = product of dielectric constant ϵ' and power factor

This equation indicates that the power density is directly proportional to the frequency, f. Assuming the loss factor, ϵ'', and voltage gradient, E_1, to remain constant, it

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FUNDAMENTALS

To utilize industrial dielectric heating efficiently, the basic theory of the technique must be considered. Power requirements, thermal losses, characteristics of the load, and types of networks for matching the load to the oscillator are discussed

It is clear that the heat energy generated in a dielectric increases as the frequency increases. For a constant frequency and loss factor, e'', the heat generated in the dielectric is proportional to the square of the voltage gradient, E_1.

The loss factor, e'', is made up of two factors, the dielectric constant and the dielectric power factor. Both of these may vary with a change in frequency, with moisture content, temperature and pressure. Therefore, during a heating process, the heat generated may not be uniform with time because of changing properties. Any change in the loss factor will involve a change in the impedance of the load and therefore a voltage and current change.

A careful study of the problem should be made at the particular installation. Thus, consideration can be made of the initial conditions such as (1) the particular set-up that will be used in order to account for stray and mutual reactances, (2) the load properties, moisture content and initial temperature, and (3) humidity which often limits the desired electrode voltage. Equation 1 is sufficiently accurate for making estimations and is used here for that purpose.

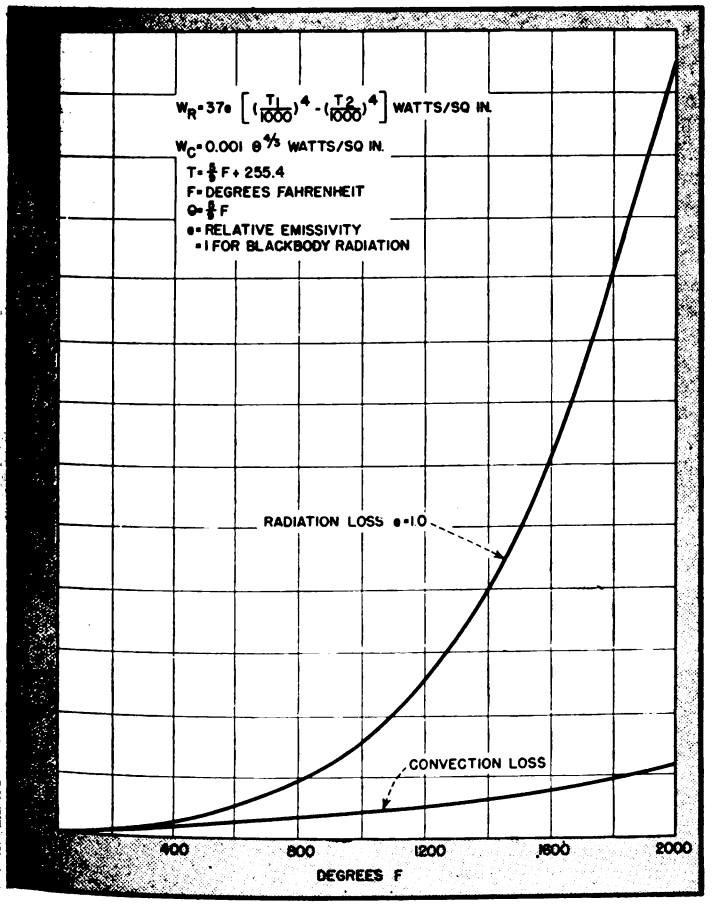

FIG. 1—Curves showing radiation and convection loss from surface in free air that were plotted at 75 degrees Fahrenheit

Determining Losses

The thermal power requirements may be specified by the general heat equation (neglecting thermal losses)

$$P = 17.6\ mc\ \Delta T \text{ watts} \qquad (2)$$

where m = lb of material heated per minute
c = Specific heat
ΔT = Temperature rise F

In some dielectric heating work, thermal losses such as convection, radiation, and conduction should be considered. The conduction loss is rather complicated, especially in the use of presses, and should be considered as an individual problem. The convection and radiation losses may be considered more general. The curve of Fig. 1 indicates approximately the radiation losses for surfaces whose relative emissivity is unity. The radiated power is proportional to the relative emissivity of the surface; therefore, blackbody radiation (unity relative emissivity) times the relative emissivity of the surface will indicate the radiated losses. Tables of the relative emissivity of various surfaces may be found in handbooks.

The curves of Fig. 1 indicate the

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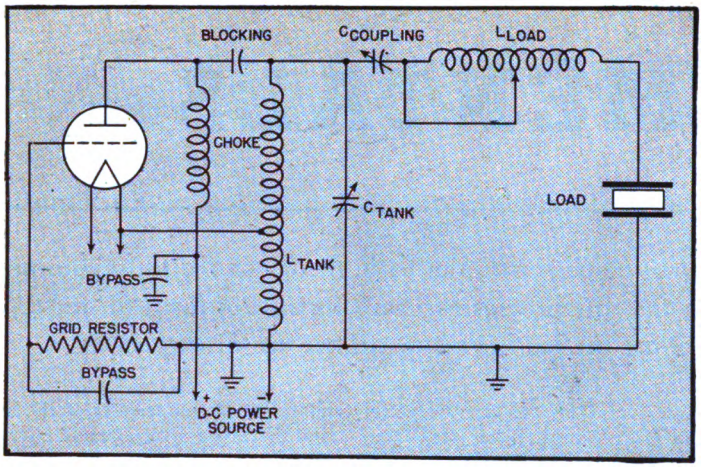

FIG. 2—Basic circuit of 2-kw oscillator for dielectric heating

radiation losses of a blackbody and convection losses for a particular temperature assuming the ambient, T_a, is 75 F. To give the true radiation loss, the blackbody radiation should be multiplied by the relative emissivity of the surface. By use of these curves or by substituting the temperature values into the equations, the losses may be determined.

For accurate determination of radiation and convection losses, these curves should be integrated over the temperature range of the load-heating cycle. Graphical integration is sufficiently accurate for most purposes. Over very short distances, the curves may be assumed to be straight lines and an average made of the sum of the initial and final radiation and convection losses.

The power density P_v used in this discussion is the required total thermal power P per cubic inch of material heated. The total thermal power includes thermal losses as well as the power required to heat the load as desired.

Three application problems are considered here. The first is the determination of the available power density for a given frequency, voltage gradient, and loss factor. This may be determined from Eq. 1.

Typical Conditions

In the second case, the frequency is fixed and the desired power density and loss factor are predetermined. The required voltage gradient E_1 in kv per inch is

$$E_1 = \left(\frac{0.7P_v}{fe''}\right)^{0.5} \qquad (3)$$

Assume that a fixed-frequency oscillator is to be applied to a load. The material specifies the loss factor e'', at a frequency f. To generate the desired power in the load for a given frequency, power density, and loss factor, the required voltage gradient may be determined from Eq. 3.

The third case will be governed by the fact that the required power density P_v and loss factor e'' are predetermined. A practical electrode voltage is assumed, being based on available voltage and electrode assembly. Then the required frequency in mc may be determined by

$$f = \frac{0.7P_v}{E_1^2 e''} \qquad (4)$$

Equation 4 determines the required frequency for an estimated maximum electrode voltage. If E_1 is a maximum, the frequency may be increased, thus requiring a decrease in E_1.

Causes of Nonuniform Heating

Generally, a frequency range of from 2 to 200 megacycles is used in dielectric heating processes. In selecting frequency, consideration must be made for the allowable voltage gradient the dielectric media will withstand at various frequencies as well as creepage along the surface of the dielectric between electrodes. Once the voltage gradient has been chosen, the desired power density and the dielectric properties of the material specify the required frequency.

Another matter of importance to consider relative to the frequency choice is the geometry of the load. The electrodes act as open-circuited electric lines. If these lines are long comparable to the wavelength, appreciable voltage nonuniformity will result, which means a nonuniformity in voltage gradient. Since the heating is proportional to the square of the voltage gradient, care must be taken to provide means of assuring approximately uniform voltage gradient in the dielectric from one point to another. If, from the point of line connection on the electrode to any other point on the electrode, there is a distance greater than one-sixteenth wavelength, appreciable voltage difference will result which will cause

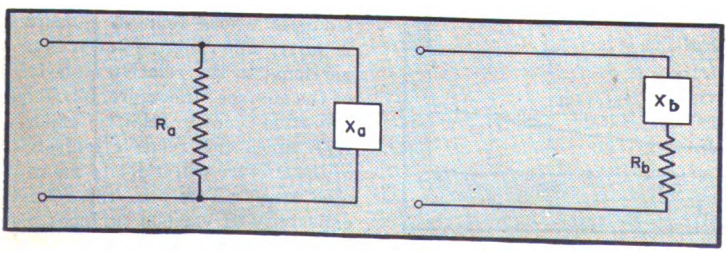

FIG. 3—Single-element network

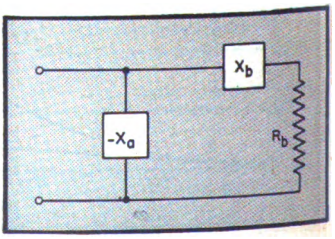

FIG. 4—Two-element L network

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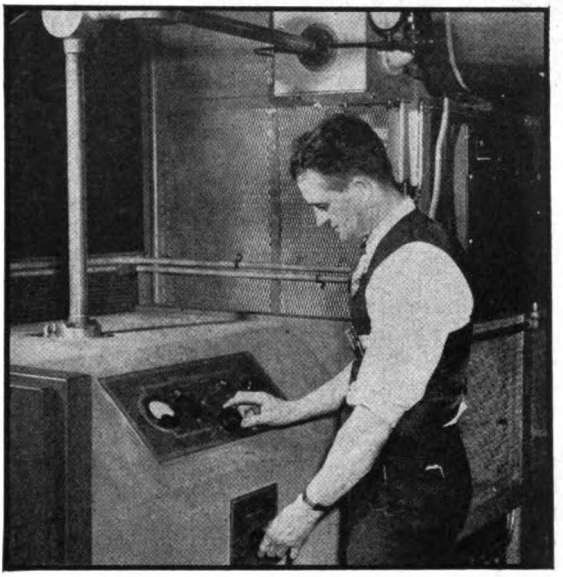
Thermosetting resin preforms are preheated in a 2-kw 30-mc generator prior to injection molding



In this installation, a standard 10-kw 5-mc electronic generator is used to dry nonconducting material

nonuniform heating of the load, where the wavelength in feet along the electrode is

$$\lambda = \frac{984}{f\sqrt{e'}} \qquad (5)$$

where f = Frequency in megacycles
e' = dielectric constant of the material heated

If electrode length is such that appreciable nonuniform heating results, arrangements should be made to feed the electrode at more than one point. Possibly networks will be needed to supply power properly to various points on the electrodes.

Load Characteristics

Most dielectric heating is done with the load material between two parallel electrodes. It is necessary to know the reactance of this load. The reactance in ohms is

$$X = \frac{1}{\omega C} \qquad (6)$$

where $\omega = 2\pi f$
f = frequency in cps

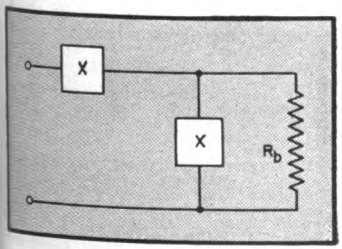


FIG. 5—Network with reactive load

$$C = 0.224\,\frac{A}{d}\,e' \times 10^{-12} \text{ farads}$$

A = Area of one electrode in sq in.
d = Distance between electrodes in inches

To represent a capacitor with losses, a perfect capacitor may be visualized with either a resistor in series or a resistor in parallel with it. Thus, losses in a capacitor may be thought of as being generated in the resistance. The effective series resistance may be represented by

$$R_1 = |X| \text{ (power factor)} \qquad (7)$$

and the equivalent shunt resistance by

$$R_2 = \frac{|X|}{\text{power factor}} \qquad (8)$$

The series resistance representation will be used throughout the rest of this discussion and unless otherwise indicated R_1 will be represented by simply R_b.

Equations 6 and 7, if properly applied, determine the load characteristics. The load impedance is, in vector form,

$$Z = R_b + jX \qquad (9)$$

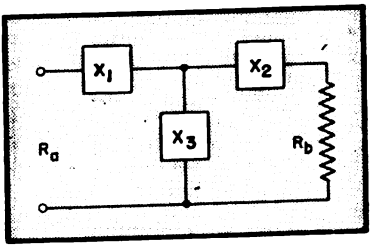


FIG. 6—Three-element T network

Today, high-frequency power is almost universally produced by vacuum-tube self-excited oscillators. These generators produce power fairly efficiently at frequencies from 2 to 200 megacycles. There are now available vacuum-tube generators capable of producing from 1 to 25 kilowatts up to 50 megacycles. Powers up to 100 kw are available at frequencies up to 20 mc and powers up to 175 kw may be obtained for frequencies up to 10 mc. The very-high-frequency generators are as yet limited to a few hundred watts. Figure 2 illustrates the circuit of a typical standard 2-kw 30-mc industrial r-f generator.

Impedance Matching

For these r-f generators there is an optimum load impedance for a required power output. If the impedance of the load happened to load the oscillator properly, no matching network would be needed. In practically all cases, however, some kind of network is needed to convert the voltage and current available at the tank coil into the voltage and current needed through the resistance of the load to cause the correct amount of heat to be generated in the work. In some

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cases the work is located close to the tank circuit; in others, it may be a considerable distance away. When the distance from the oscillator to the work is more than about one-eighth wavelength, a nonresonant transmission line is generally employed, necessitating two coupling networks, one at each end.

In general, there are three types of network that may be used, one, two, or three element. The configuration may be either T or π. Each element of the network offers control over one characteristic of the network.

A single-element network can be used to match the resistance of the load to the oscillator provided the reactive component is not important. If the input of the network is connected directly across the tank circuit of the oscillator, a reactive component reflected from the load will shift the frequency slightly. This is usually unimportant. The action of this network is merely to provide a series impedance which may be used to control the current passing through the resistive component of the load. Usually the largest part of this impedance is the reactance of the load. One great advantage of this type of network is that changes in dielectric properties of the load cause relatively minor changes in loading.

Effect of Reactance

The shunt resistance that must be reflected back across the tank coil can be found from the relation $R_a = E_t^2/P$, where E_t is the available rms voltage and P the power in watts. R_a is the resistance in ohms to be reflected across the tank coil.

Referring to Fig. 3, the two impedances are equal at the terminals if

$$R_a = \frac{R_b^2 + X_b^2}{R_b} \qquad (10)$$

$$X_a = \frac{R_b^2 + X_b^2}{X_b} \qquad (11)$$

Assume it is required to match a load of R_b ohms to a generator which is properly loaded by R_a ohms. Re-arranging Eq. 10,

$$X_b = \pm \sqrt{R_a R_b - R_b^2} \qquad (12)$$

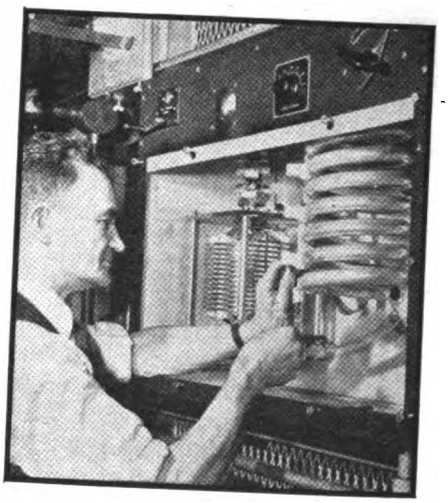
It will be noticed that if R_b is greater than R_a, then X_b will be an imaginary number, an impossible condition, therefore this network may not be used.

X_b is the total series reactance including the reactance of the load, and may be either inductive or capacitive. In dielectric heating, the reactance of the load is always capacitive so it is advisable to make the total reactance capacitive. In this way the stored energy in the load circuit is kept to a minimum and the oscillator is more stable.

The reactance reflected across the tank can be found from the relation

$$X_a = \pm R_a \sqrt{\frac{R_b}{R_a - R_b}} \qquad (13)$$

In this equation, the sign of X_a will be the same as the sign X_b in Eq. 12.



A coupling network which enables power to be removed from the material without shutting down the generator

If it is necessary to have the input impedance of the network purely resistive, the input may simply be shunted with a reactance of X_a, but of opposite sign. This configuration gives a two-element network commonly known as an L network, as shown in Fig. 4.

In both networks shown thus far, R_a must be greater than R_b. There are cases, however, where R_b is greater than R_a. The circuit shown in Fig. 5 cannot be used because the load has a reactive component. It is necessary therefore to use a T network as indicated in Fig. 6.

Since this T network has three elements, three characteristics may be varied. These three characteristics are resistance, reactance, and phase shift. In dielectric heating, phase shift is usually ... cern, so that arbitrarily ... one element of the netw... picked. Then the rem... elements may be calcula... rect resistance and re... resulting phase shift ... lected.

The load has a series ... let this reactance be ter... calculate X_1 and X_2 fro... tions

$$-R_a R_b = X_1 X_2 + X_1 X_3$$

and

$$\frac{R_a}{R_b} = \frac{X_1 + X_3}{X_2 + X_3}$$

In considering therma... must bear in mind tha... thermal conduction los... constitute the absorptio... by material in contact w... load. In the case of diele... ing, the contacting elec... absorb energy. The rate... tion depends upon the te... differential, the geomet... absorber and the load, ... thermal properties. If i... tion the dielectric heating ... are used almost continuo... will absorb sufficient energ... their temperature to abou... the final load temperatu... conduction losses equal t... tion and convection losses ... electrodes. Radiation and ... tion losses will also occu... sides of the dielectric load.

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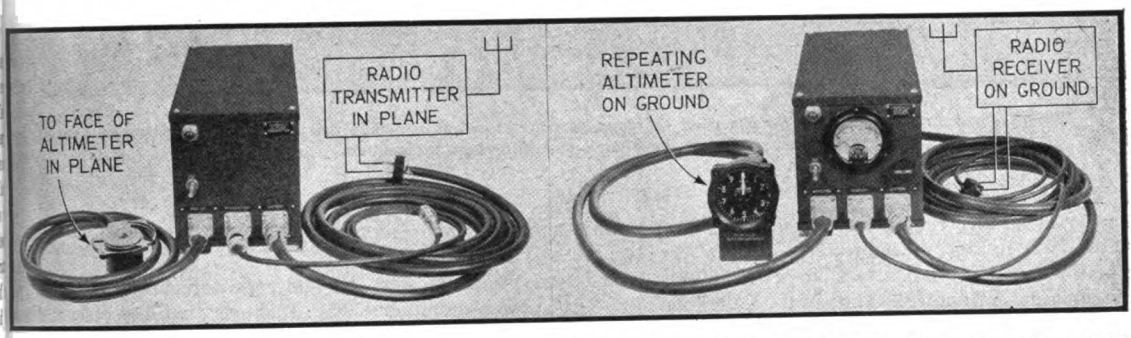
Plane-to-Ground RADIO TELEMETERING

Electronic system utilizing phase angle as transmission means for radio link permits reading altimeter and other instruments from ground during flight-testing or in radio-controlled aircraft. Mounting of small magnet on pointer is only alteration to instrument



Left: Pickup chassis used in plane, with pickup and connecting cable, battery cable, and output cable going to transmitter. Right: Chassis used on ground, showing repeating altimeter and connecting cable, input cable going to receiver output, and battery cable

By DAVID W. MOORE, JR.

Engineer,
Fairchild Camera and Instrument Corp.
New York, N. Y.

IN MANY INSTRUMENTATION SYSTEMS it is desirable or necessary to have an indication of the measured value at some distance from the point of measurement. This is particularly true in aircraft flight testing, or in the flying of radio-controlled aircraft. In installations of this type it is frequently advantageous for reasons of safety to remove all personnel from the aircraft being tested or flown by radio control systems. It then becomes necessary to have a means for reading the flight instruments, particularly, at some remote point. For this, radio is the only practical communication link.

Quite a number of systems have been and are being developed to serve this purpose. These range from telemetering devices producing a graphical indication of the phenomenon being studied, to systems which faithfully reproduce a dial indication similar or equal to that which would be seen by the pilot if he were present in the plane. Systems of the latter type are particularly desirable in flying radio-controlled aircraft, since they preclude any necessity of having to train an experienced pilot to become familiar with new instruments.

This article describes a telemetering system which permits reading a standard aircraft instrument with very slight modification to the instrument itself, transmitting this reading to any desired remote position or positions, and reproducing faithfully the initial indication on a dial equivalent to that of the aircraft instrument.

All possible means for transmitting intelligence were studied for application to a particular installation which required the transmission of the indication of a standard sensitive altimeter. As a continuous indication was required, all of the step-by-step impulse systems were eliminated. It was also deemed undesirable to employ any amplitude comparison arrangements over a radio link which might seriously affect amplitude values. After much consideration it was decided to use electrical phase angle as the transmission means.

Phase-shifting Pickup

An instrument indication pickup was designed which coupled magnetically to the sweep pointer of the sensitive altimeter, and which shifted the phase of its input signal degree for degree with the motion of the sweep pointer. In other words, for a 90-degree shift in the position of this pointer, the electrical phase angle of the output signal of the pickup would shift 90 electrical degrees with reference to the input signal.

The pickup was designed to mount directly on the sensitive altimeter, as shown in the accompanying photographs. No alterations were necessary to the altimeter other than the mounting of a small permanent magnet on the hub of the sweep pointer. This magnet enabled the use of magnetic coupling to the position pickup and the maintaining of the pressure seal of the instrument.

The position-receiving instru-

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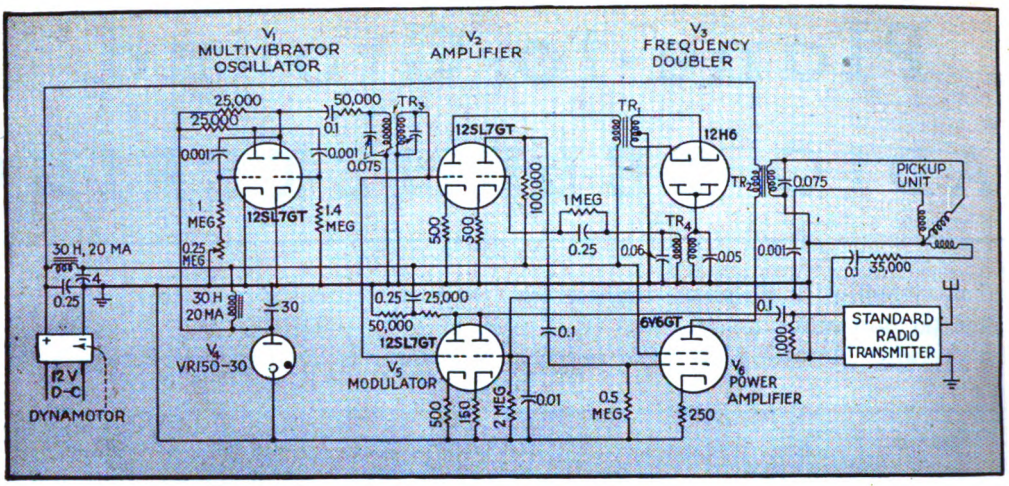

FIG. 1—Schematic diagram of chassis used in plane to convert output of pickup unit into signals that can be handled by one of the plane's standard radio transmitters

ment was an electrical phase-angle meter with its output connected to a pointer system similar to that in the original altimeter. The similarity of this component to an actual altimeter is apparent from the photographs.

Schematic diagrams of the electronic components of the position transmitting and receiving systems are given in Fig. 1 and 2. The operation of the transmitter will be taken up first.

Transmitter Circuit

To transmit intelligence by electrical phase angle, it is necessary to transmit a reference signal to be used as a time or phase standard, as well as the intelligence signal. The comparison signal and the intelligence signal are transmitted as two separate audio frequencies on one radio-frequency carrier.

Referring to the pickup chassis diagram in Fig. 1, V_1 is a double triode (12SL7GT) acting as a 250-cps multivibrator oscillator. The 250-cycle wave passes through tuned transformer TR_3 to one half of V_2 (12SL7GT) acting as an amplifier for the frequency-doubling circuit including V_3 (12H6), and to one half of V_5 which acts as a modulator for the radio transmission system. Tube V_4 rectifies the 250-cycle signal, producing a strong second harmonic component which is selected by tuned transformer TR_4 which is tuned to 500 cycles. This second harmonic signal is then fed into the second half of V_2 which amplifies it and feeds it into power amplifier V_6. This power amplifier energizes the phase-shifting pickup whose output is fed to modulator V_5 and combined with the original 250-cycle signal which is used as the reference signal. The phase angle between the input of the phase-shifting pickup and its output is a function of the position of the altimeter sweep hand.

The output of the modulator tube is fed into a standard radio transmission system capable of being modulated by 250 and 500 cycles and having a small fixed phase shift between the two signals. For testing, a frequency-modulation radio transmitting and receiving system was used.

Repeater Circuit for Receiver

The repeater chassis diagram in Fig. 2 shows that the output from the radio receiver energizes two filter systems starting with the first halves of V_1 and V_2 (both 12SL-7GT). The output from the first half of V_1 is filtered by TR_1, which passes only the 500-cycle component to the second half of V_1 for energizing the zero-setting phase-shifting device that excites power amplifier V_6 (6V6GT). In turn, V_6 feeds into phase one of the two-phase drag-cup motor driving the phase meter indicator.

The first half of V_2 is connected to TR_2, which passes only the 250-cycle reference component of the received signal. This 250-cycle component is amplified by the sec-

Left to right: Pickup unit that attaches to face of instrument on plane; altimeter on plane, with small permanent magnet attached to its pointer; altimeter with pickup

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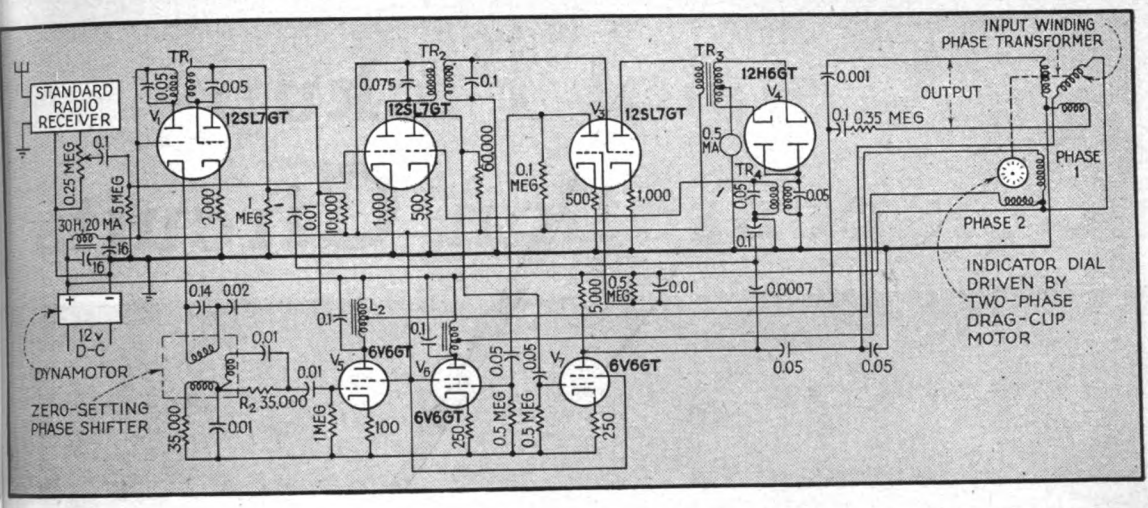
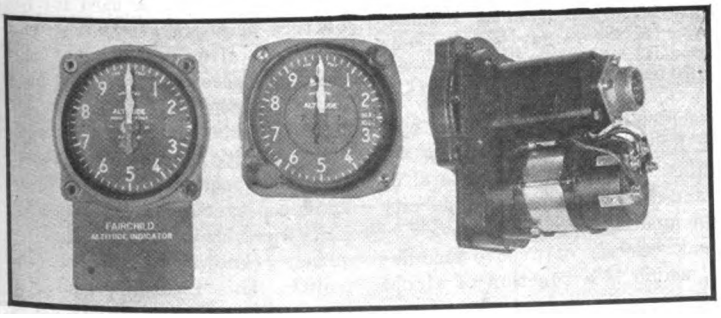


FIG. 2—Schematic diagram of chassis used on ground to convert output signals of receiver into currents suitable for driving an indicator that repeats accurately the readings of the instrument on the plane

ond half of V_3 and then fed through TR_3 for rectification by V_4, producing a strong second harmonic component which is selected by TR_4, producing a reference signal of the same frequency as the intelligence signal and therefore easily compared with it by a phase angle meter. This 500-cycle component is amplified by V_2 and V_7 and fed into a phase transformer driven by the two-phase drag-cup motor. The output of this phase transformer is amplified again by amplifiers V_5 and V_6, which in turn excite phase two of the two-phase meter indicator.

The two-phase motor will develop torque when there is any phase angle difference between the currents in phase one and phase two of the motor. Phase one is, as mentioned heretofore, excited by the amplified 500-cycle component of the received signal. Phase two is excited by the comparison signal, doubled in frequency and shifted in phase by the phase transformer in the motor-driven phase angle meter. The phase transformer position for zero phase angle between the currents in phase one and phase two of the motor is then a function of the difference in phase between the intelligence and the comparison signal in the received wave, which is in turn a function of the altimeter reading. The phase transformer operates the indicating pointer directly. Any discrepancy between the position of this phase transformer and the sensitive altimeter shaft which might be due to electrical phase shifts in the radio transmission equipment and in the transmitting and receiving electronic units is compensated at the time of installation by adjusting the zero-setting phase shifter. This adjustment only has to be made once for each installation.



Front and rear views of repeater used on ground, with standard altimeter (center) shown for comparison

Performance and Applications

Complete flight tests were made of this equipment by the Aircraft Radio Laboratory at Wright Field, Dayton, Ohio. The position-transmitting equipment was mounted in an AT7 aircraft and favorable results were obtained within the range of the radio equipment. It was noted that when the aircraft was flown out of the range of the radio equipment, the phase meter indicator maintained the indication at the point of losing radio contact, taking up the correct reading instantaneously again upon reestablishment of the radio contact.

A system of this type is also applicable to multichannel instrument transmission on one radio carrier. For this use one comparison signal is employed with a multiplicity of intelligence waves, permitting a compact and accurate system for transmitting the entire flight group of instruments.

For industrial telemetering, the radio link may be eliminated, providing accurate and flexible multichannel or single-channel telemetering adaptable to carrier current or wire service.

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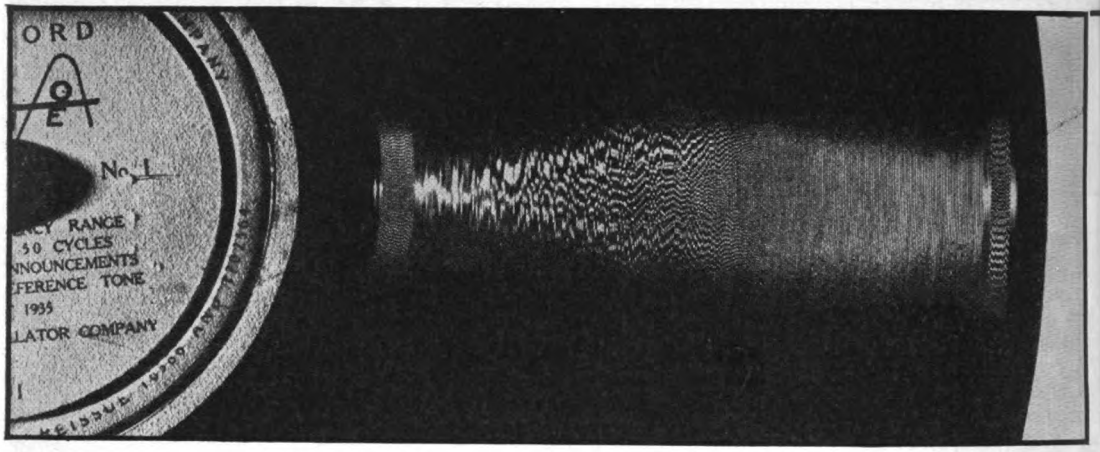
Crystal Pickup Compensation Circuits



Light pattern on test record indicates frequency-response characteristic

From consideration of recording practice, record properties, pickup frequency characteristics, and listener acceptance, the appropriate corrective network for connecting crystal pickup to amplifier input to give desired overall frequency response is determined

IN THE DESIGN of phonograph equipment, quality performance is not automatically assured by choosing better-grade components for the playback mechanism. The circuit connecting the pickup to the amplifier plays an important part in the satisfaction which the user obtains from the instrument. A clear understanding of the latest trends in recording characteristics is essential to the selection of this circuit. In this article general consideration is given to the frequency response of phonograph playback equipment, with particular attention to the design of circuits for connecting piezoelectric pickups to playback amplifiers.

Recording Characteristics

To reproduce a record in the manner intended by the recording director, the characteristic of the playback system should match the characteristic of the recording system. Recording characteristics are specified in terms of the lateral or hill-and-dale amplitude and velocity of the modulated record groove.

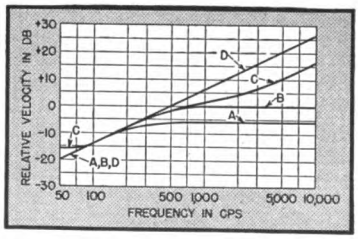


FIG. 1—Theoretical recording characteristics for (A) 250-cps turnover, (B) 500-cps turnover, (C) N.A.B. lateral recording, and (D) constant-amplitude recording

Peak velocity of groove modulation, which is a function of signal frequency is commonly known as the modulation velocity. If modulation velocity is to remain constant, amplitude must decrease with the frequency.

Recording characteristic of a system is defined by the velocity-frequency or amplitude-frequency curve obtained by cutting a disk with a sinusoidal voltage of constant amplitude and varying frequency applied to the input terminals of the recording amplifier. In this manner a test record is obtained which can be used for calibrating playback systems.

Shortly after the introduction of electrical recording, cutting heads and recording circuits were adjusted in such a manner that a constant velocity characteristic was obtained at frequencies above 250 cps, and a constant amplitude characteristic was obtained below this frequency (known as the turnover point). This recording characteristic is shown by curve A in Fig. 1. Maximum modulation velocity above the turnover point was limited—by the ability of the relatively heavy pickup needle chucks to turn the

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By B. B. BAUER
Chief Engineer, Shure Brothers
Chicago, Ill.

Overall frequency characteristic of a portable record player is measured by means of a calibrated microphone and sound level meter

corners of the modulated groove at high frequency—to approximately 2.5 inches per second. The modulation amplitude below the turnover point was limited by the pitch of the grooves to approximately 0.002 inches. Disks recorded with this characteristic gave satisfactory tonal balance with equipment available at the time.

Extension of the frequency range by lightening the moving system of phonograph pickups, together with the development of wide-range loudspeakers for home use, led to the increase of the high-frequency modulation velocity to peaks of 5 to 7 inches per second. This resulted in a substantial improvement of the signal-to-noise ratio. Because of groove spacing limitations, maximum low-frequency modulation remained unchanged and the turnover point was shifted upward to 500 cps in home records. Such a recording characteristic is shown by curve B in Fig. 1. Because the surface-noise energy is contained principally above 1000 cps, this recording characteristic provides an improvement of signal to surface-noise ratio over the 250-cps turnover point characteristic of approximately 6 db.

High-Frequency Pre-Emphasis

To diminish the audibility of surface noise in transcriptions, it became common practice to accentuate the high-frequency characteristic in the cutting-head amplifier, and conversely, to attenuate the high-frequency response of the pickup. An example of such a recording characteristic is the orthoacoustic characteristic employed by the National Broadcasting Company, which provided for a 16-db rise at 10,000 cps. In 1942 the National Association of Broadcasters[1] recommended as standard the characteristic shown by curve C in Fig. 1, which corresponds closely to this

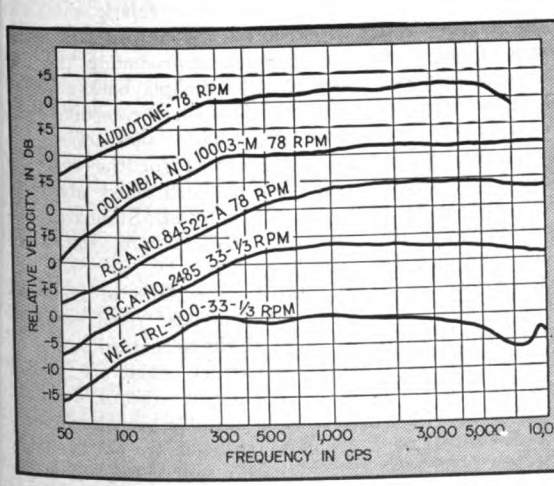

FIG. 2—Measured velocity-frequency characteristic of several test records

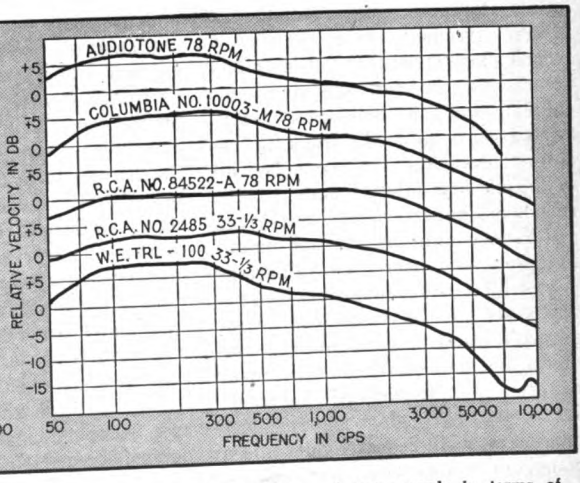

FIG. 3—Playback characteristics of test records in terms of N.A.B. response

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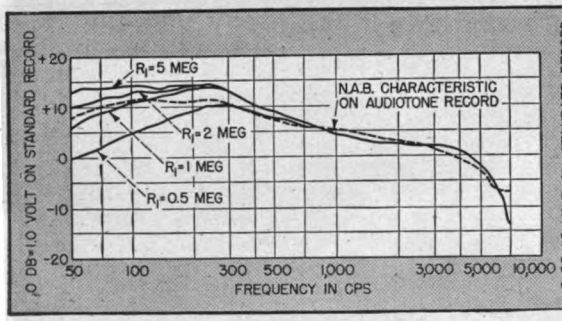

FIG. 4—Terminating resistance affects the low-frequency response of crystal pickups and therefore can be used to adjust overall response

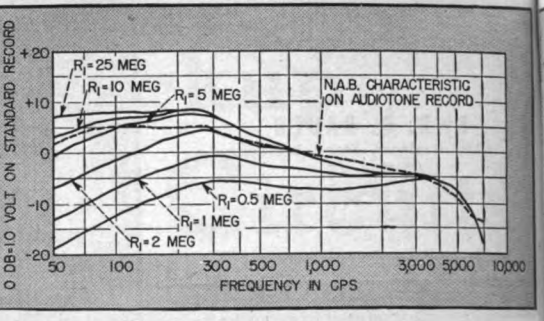

FIG. 5—By choosing terminating resistance used with PN type cartridge, N.A.B. characteristic can be approached. Five megohms gives best match

orthoacoustic characteristic.

In addition to high-frequency pre-emphasis, the recommended standard indicates a low-frequency pre-emphasis. When compensated in the appropriate manner, low-frequency pre-emphasis, tends to diminish effects of turntable rumble and line frequency hum.

If the recorded amplitude is kept at a low value, it is possible to employ a constant-amplitude recording characteristic shown by curve D in Fig. 1. Such a characteristic has a number of advantages, among them that of efficiently utilizing the available record surface and of providing a high signal-to-noise ratio. This characteristic has not been extensively applied.[2]

Characteristics of Shellac Pressings

The manufacturer of home records is confronted with a number of factors which have a bearing upon response-frequency characteristics. Home records are employed in an extremely wide variety of record players with different characteristics, in coin-operated machines, and in broadcast work. Such factors as needle tracking, recorded level, and surface noise, all of which are interdependent with response characteristics, are given different weight by various manufacturers and users. One finds, as a result, a difference between response-frequency characteristics of records manufactured under various brand names. Because of these differences in recording characteristics, a single playback response cannot meet all requirements and a compromise must be sought. It is to be expected that standardization work may be done in the future to remedy this situation.

Many recent recordings exhibit a good tonal balance when played back with a pickup adjusted to conform to the N.A.B. Standard. Other records provide a better balance when reproduced with a pickup which is flat on a velocity basis beyond the 500-cycle turnover point. However, surface-noise considerations in shellac-type home records dictate a reduction of high-frequency response of the playback roughly in accordance with the N.A.B. Standards. For reasons which are stated later, attenuation greater than prescribed by N.A.B. Standards is often desirable beyond 4,000 to 5,000 cps. There is little doubt that useful frequency content in commercial records beyond 8,000 cps is negligible.

Playback Tests

Test records provide convenient and precise means for testing and adjusting the response of playback systems. The test record need not be recorded with the exact characteristic which is desired for the playback system, as long as its characteristic is known. Most test records are recorded with a constant amplitude characteristic up to the turnover point, and a constant velocity characteristic above the turnover point.

Among American-made lateral test records are Audiotone No. 78-1 (250 cps turnover), Columbia Frequency Record No. 10003-M (300 cps turnover), and R.C.A. Frequency Record No. 84522 (500 cps turnover). These are 78-rpm records intended for use with home record players. For broadcast test work R.C.A. Orthoacoustic No. 2485 (500 cps turnover) and Western Electric Test Record TRL-100 (250 cps turnover) 33⅓ rpm records are available.

Frequency characteristics of test records are sometimes supplied by the manufacturers, but they can also be obtained by measurement of the width of reflected light pattern[3], or by measurement with a phonograph pickup which is known to be substantially flat and to have low needle-point impedance.

Velocity-frequency characteristics of the above test records, as measured in the Shure Laboratory, are shown in Fig. 2.

Procedure for obtaining the playback characteristic of a test record in terms of a given recording curve is to subtract the desired recording characteristic from the frequency characteristic of the given test record. The resultant curve is the overall characteristic which will be exhibited by the playback mechanism when reproducing the test record with the playback adjusted to match the desired recording characteristic. This subtraction has been performed for the first five test records mentioned above in terms of the N.A.B. Standard. The resulting curves are shown in Fig. 3.

Precise adjustment of the playback characteristic requires measurement of the acoustical output of the loudspeaker when the pickup is playing the test record. In practice, when suitable acoustical measurement facilities are not available the pickup output voltage is measured across the amplifier volume control; the characteristic of the

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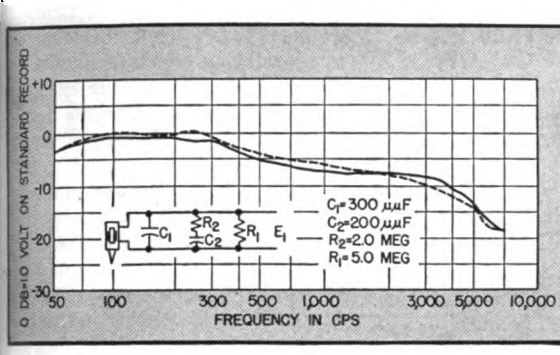

FIG. 6—Solid line is response of PN pickup cartridge with compensating network; dash line is Audiotone record response adjusted to N.A.B. Standard

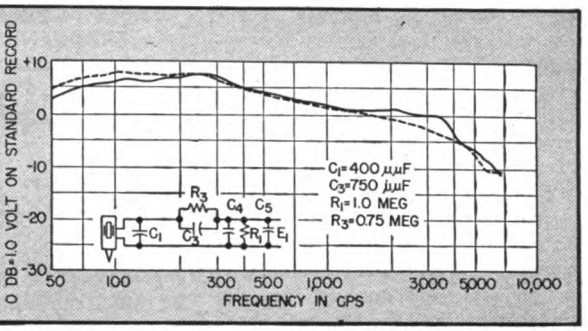

FIG. 7—Similar curves to those of Fig. 6 but for crystal pickup. Both the curves of Fig. 8 and this figure are for response with bent-shank aluminum needle

amplifier and the loudspeaker is then added to these readings to obtain the overall characteristic.

Crystal Pickup Characteristics

Two types of piezoelectric crystals are employed in phonograph pickups, the x-cut rochelle salt type and a new crystal developed by the Brush Development Company known as the PN type. Rochelle salt crystal pickups are characterized by high output voltage and high internal capacitance. PN crystal pickups have acoustical characteristics similar to the crystal pickups, with the added advantage of withstanding extremely high ambient temperatures without deterioration. On the other hand, PN crystal pickups have a low internal capacitance which requires careful design of the input circuit for optimum operation.

From the electrical standpoint, a piezoelectric pickup can be represented as a zero-impedance generator connected in series with a capacitance which is numerically equal to the capacitance of the crystal. This capacitance is approximately 1000$\mu\mu$f in the case of rochelle salt pickups, and is approximately 100 $\mu\mu$f in the case of PN pickups. The addition of a capacitive cable to the pickup terminals results, therefore, in a loss of output voltage without change in frequency characteristic. The loss in output can be calculated by considering pickup capacitance C_0 and cable capacitance C_1 as forming a capacitive voltage divider. The loss due to cable, in decibels, is 20 log $(1 + (C_1/C_0))$, indicating the desirability of connecting the pickup to the amplifier with a cable having the lowest possible capacitance.

Phonograph pickups are generally connected to potentiometer-type volume controls. Because the internal impedance of the pickup is capacitive (and therefore increases at low frequencies), the addition of the volume control across the pickup causes a drop in output at low frequency. The added loss due to the shunting effect of the volume control resistance, in decibels, equals 20 log $[1 + (1/\omega CR_1)^2]^{\frac{1}{2}}$ where C is the sum of the capacitance of pickup and cable $(C_0 + C_1)$ in microfarads, and R_1 is the volume control resistance in megohms.

Input-Circuit Loading

To illustrate the point, Fig. 4 shows the characteristic on an Audiotone record of a Shure P-87 rochelle salt pickup cartridge connected across resistances of 0.25 megohms to 5.0 megohms. In dotted line is shown the playback characteristic which should be attained on an Audiotone record in order to match the N.A.B. Standard Characteristic. (This is obtained from Fig. 3.) It is seen that with this particular rochelle salt pickup, a 1.0 megohm volume control provides the best fit to the N.A.B. characteristic.

Figure 5 shows the characteristic of a PN-87 type pickup cartridge connected across resistances of 1.0 megohms to 10 megohms. In this instance, a 5-megohm termination resistance provides the most satisfactory performance. (It should be noted that the 100-$\mu\mu$f capacitance of the vtvm leads has doubled the effective generator capacitance.) Where such high termination resistance is not desirable, it is permissible to connect a 0.0008-microfarad capacitor across the PN pickup. This expedient results in a 15-db drop in the output voltage, but good performance can then be obtained with a 1.0 megohm termination resistance or potentiometer volume control.

Pickup input circuits of the simple potentiometer type do not, in general, provide completely satisfactory performance, but they can be employed in low-cost sets.

Low-Frequency Compensation

One of the earliest circuits employed for low-frequency compensation in piezoelectric pickups is shown in Fig. 6. The pickup is shunted by a series combination of capacitor C_2 and resistor R_2. At low frequency, R_2 is less than the capacitance of C_2, and therefore R_2 can be neglected. C_0, C_1, and C_2 form a capacitive voltage divider which reduces the low-frequency response evenly without frequency discrimination. At higher frequency, $X_c <$ R, and the effects of the capacitor become gradually less important. In the design of this circuit, C_2 can be calculated from loss = 20 log $[1 + (C_2/C)]$ db, where C is the sum of the capacitances of pickup and cable, $(C_0 + C_1)$, based upon the desired low-frequency loss R_2 is adjusted to equal X_{C_2} at the frequency above which compensation is no longer desired.

Because of changes of capacitance of x-cut rochelle salt crystals with temperature, low-frequency compensation can vary several decibles over the temperature range

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of 76° to 90° F; however, if PN crystals are used this is not encountered. On the other hand, this circuit has the advantage of not being adversely affected by cable capacitance between the parallel branch and the volume control.

Figure 6 shows the Audiotone record response of a Shure PN-87 pickup cartridge connected to a network having the indicated circuit components. Response of this circuit matches well the playback characteristic of the Audiotone record adjusted to the N.A.B. Standard Characteristic.

Another low-frequency compensating circuit, introduced by the writer several years ago for use with rochelle salt crystal pickups, is shown in Fig. 7. It consists of a parallel combination of a capacitor C_3 and a resistor R_3 connected in series between pickup and volume control. This circuit presents a high impedance to the crystal at low frequency and therefore diminishes the effects of capacitance-temperature variations. In computing this circuit, R_3 and R_1 are treated as a voltage divider at low frequency. X_{C3} is then made equal to R_3 at the frequency above which compensation is no longer desired. Stray capacitance C_4 and C_5 should be kept to a minimum to avoid a shunting effect upon R_1 at high frequency.

By the way of example, Fig. 7 shows the response-frequency characteristic of a Shure P-87 pickup employing a version of this circuit in which the network elements have the indicated values. By comparison with the N.A.B. Standard shown in broken line, it is seen that the two are in substantial agreement.

High-Frequency Compensation

Because the recording characteristic varies from one record to another, it is not feasible to specify with precision what response is apt to produce the most faithful reproduction. As has been pointed out, records appear to produce best fidelity when the response above 1,000 cps is flat on a constant velocity basis. Some of the newer recordings provide excellent results when played with a pickup adjusted in accordance with the N.A.B. Standards. For maximum flexibility, it appears best to have a pickup with an inherent high-frequency response somewhat higher than that required by the N.A.B. Standards. This response can be lowered, if necessary, by means of a conventional tone control circuit incorporated in later stages of the amplifier.

TABLE I—PREFERRED HIGH-FREQUENCY CUT-OFF

Cut-off Frequency	Non-tech. Listeners	Technical Listeners
3,000 cps	71%	13%
5,000 cps	21%	58%
above 5,000 cps	8%	29%

The high-frequency range most acceptable to the listener is determined, to a large extent, by surface noise. The surface noise energy content for various recording materials is shown in Fig. 8[4]. Surface noise energy is distributed over practically all of the audible range on the basis of approximately equal energy content per cycle. Therefore, the effects of surface noise can be eliminated most easily by removing the higher end of the frequency spectrum, which contains the most surface noise energy per octave in the range where the ear is most sensitive to low level sounds.

Listener Tests

Distortion is another factor which has an important bearing upon the optimum high-frequency cut-off of the pickup. The origin of this distortion is (a) the relatively large radius of needle tip required to track properly in conventional record groove[5], (b) distortion inherent in the process of duplicating commercial records, and (c) distortion which takes place in playback equipment. Distortion due to these causes can attain values as high as 15 to 20 percent on a direct measurement basis (not including intermodulation effects). Removal of response at high frequency is instrumental in reducing the annoyance caused by this type of distortion.

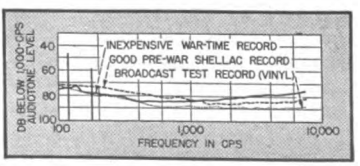

FIG. 8—Energy level per cycle of noise for various types of record material

The author has conducted a number of tests to determine the preference of listeners to high-frequency cut-off in the reproduction of home records. The tests were given to 100 non-technical listeners, and to over 100 radio engineers.[6] While a description of these tests is outside the scope of this article, the results given in Table I, although not conclusive, indicate that in the reproduction of home records, response above 5 kc exaggerates the effects of surface noise and distortion out of proportion to the improvement in fidelity. High-frequency cut-off can be obtained through the use of specially designed needles, or it can be obtained electrically with conventional low-pass filters.

The situation is, of course, totally different in the reproduction of broadcast-type transcriptions produced on low surface noise material and carefully processed to keep the sources of distortion to a minimum.

The author is grateful to the following persons for helpful discussion and for information regarding response characteristics: J. Dickert of Decca Records, Inc.; W. R. Dresser of the Audio-Tone Oscillator Company; H. S. Knowles of the Jensen Radio Corp.; V. J. Liebler of Columbia Recording Corporation; R. A. Miller of Bell Telephone Laboratories; A. A. Pulley and H. I. Reiskind of the Radio Corporation of America.

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(4) The method of obtaining this information and other factors affecting fidelity of phonograph reproduction were described by the author in a paper presented before the Chicago Section of the I.R.E. on Dec. 15, 1944.

(5) Pierce, J. A., and Hunt, F. V., On Distortion in Sound Reproduction from Phonograph Records, *Journal of the Acoustical Society of America*, **10**, p 14, 1938.

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Electronic WATTMETER

Substitution of a cathode follower for a transformer and use of a push-pull parabolic rectifier provide a sensitive, wide-range electronic wattmeter that is useful to higher frequencies and loads the circuit less than electrodynamic types

By L. R. MALLING
Seattle, Wash.

AN ELECTRONIC WATTMETER was patented in 1926 by Eugene Peterson[1], and although a few years later Turner and MacNamara described a phase-shifting bridge adaption of this original circuit, little real use has been made of the principle.

Difficulties of measuring true power have led the electronic engineer to rely on the substitution of resistive components for reactive loads and the estimation of power from the measured current or voltage. However, continued expansion of electronics into the field of industrial engineering, use of high-frequency heating and the increasingly high frequencies used, for example, in airplane power systems, well justify an investigation into the properties and design requirements of the vacuum-tube wattmeter.

This article will discuss the limitations of the conventional a-c power wattmeter and will show how present-day circuit techniques and modern vacuum tubes may be applied to construction which will overcome the difficulties of the early design and make the vacuum-tube wattmeter a permanent and useful tool of the electronic engineer.

Advantages of Electronic Wattmeter

Average power in an electrical circuit is given by the product of $EI\cos\theta$ where E and I are rms values and θ is the phase angle between current and voltage. Average power may be measured by the power circuit engineer with an electrodynamometer, an instrument depending for its action on the average torque produced between two coils in which currents flow proportional to the applied voltage and current. It can be seen that the inductance of the coils will produce increasingly large errors as the frequency is increased and that the power absorbed by such an instrument limits the sensitivity. In addition, many electronic circuits will be seriously disturbed by the introduction of such an instrument.

Power can be measured by electronic voltmeters and ammeters in conjunction with electronic phase meters provided only single-frequency, sinusoidal voltages and currents are involved. Also slide-back wattmeters can be used where tubes can only be relied upon over a small portion of their characteristic.

Vacuum-tube wattmeters may be made independent of frequency over wide ranges and, while still retaining the advantages of high-power measurements by the use of shunts and multipliers, can also read powers of the order of fractions of a microwatt by the use of suitable amplifiers. The disturbing effect of placing the electronic wattmeter in a given circuit may be reduced

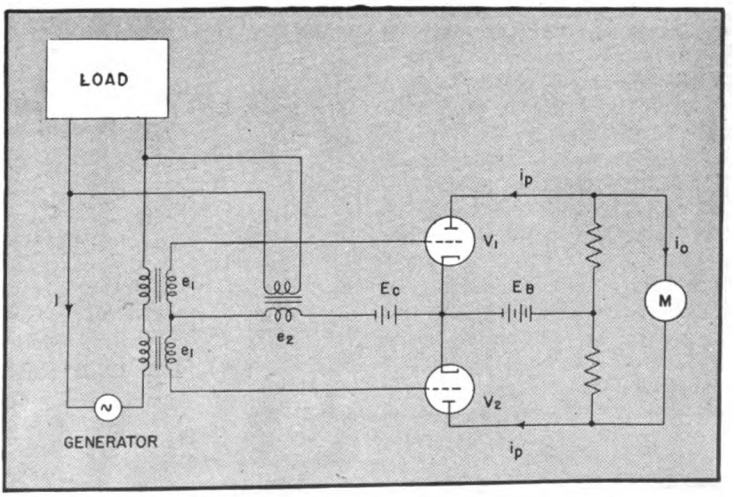

FIG. 1—Original electronic wattmeter circuit of Peterson, using transformers to compare the phase angle between potential and current

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to the level that is presently recognized for other electronic test equipment. Accuracy of reading at low power factors becomes less of a limitation and the use of square-law rectifier tube characteristics makes the electronic instrument almost completely free of waveform errors.

Early Design and Theory

Figure 1 shows the original circuit described by Peterson, which operates on the principle of the balanced modulator. Voltage and current components of the load are applied to the tubes V_1 and V_2 and the difference in their plate current is registered on meter M. The voltages applied to the grids add in one case and subtract in the other so that the change in plate current in tube V_1 is

$$i_p = a_1 (e_1 + e_2) + a_2 (e_1 + e_2)^2 \quad (1)$$

and in tube V_2 is

$$i'_p = a_1 (e_1 - e_2) + a_2 (e_1 - e_2)^2 \quad (2)$$

The difference or meter current is

$$i_0 = i_p - i'_p = 2\, a_1 e_2 + 4\, a_2 e_1 e_2 \quad (3)$$

If $e_2 = E_1 \cos \omega t$ and $e_1 = E_2 \cos (\omega t - \theta)$

$$\begin{aligned} i_0 &= 2\, a_1 E_1 \cos \omega t + 4\, a_2 E_1 E_2 \cos \omega t \times \cos (\omega t - \theta) \\ &= 2\, a_1 E_1 \cos \omega t + 2\, a_2 E_1 E_2 \times [\cos (2\, \omega t - \theta) + \cos \theta] \\ &= 2\, a_1 E_1 \cos \omega t + 2\, a_2 E_1 E_2 \times \cos (2\, \omega t - \theta) + 2\, a_2 E_1 E_2 \cos \theta \quad (4) \end{aligned}$$

and neglecting the frequency terms whose average value equals zero,

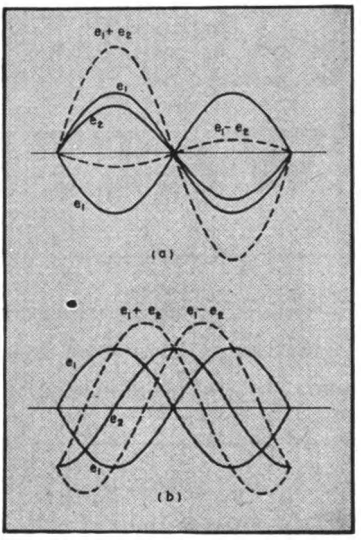

FIG. 2—Response of wattmeter reading to power factor is illustrated by (a) the addition of in-phase current and potential waves giving a large resultant meter current, and (b) the addition of out-of-phase components giving a zero resultant meter current

the meter or d-c current is

$$i_{d\text{-}c} = 2\, a_2 E_1 E_2 \cos \theta \quad (5)$$

It can thus be seen that the electronic instrument will register true power.

The manner in which the voltage and current components add or subtract for out-of-phase load conditions may be illustrated by taking the case for a 90-degree phase difference or zero power factor. Let

$$\begin{aligned} e_1 &= \sin A \text{ and } e_2 = \sin (A - 90) \\ \text{then } e_1 + e_2 &= \sin A + \sin (A - 90) \\ &= 2 \sin (A - 45) \cos 45 \\ &= 1.4 \sin (A - 45) \quad (6) \\ e_1 - e_2 &= \sin A - \sin (A - 90) \\ &= 2 \cos (A - 45) \sin 45 \\ &= 1.4 \cos (A - 45) \quad (7) \end{aligned}$$

It can be seen that two new components are introduced and that these are of equal amplitude, separated by 90 degrees representing sine and cosine functions. These give equal changes in the d-c plate current of V_1 and V_2 and thus there will be no deflection of the meter needle. Figure 2 shows graphically the sum and difference components for in-phase and out-of-phase components.

New Circuit

A modernized version of the Peterson wattmeter circuit is shown in Fig. 3. The load is supplied with power from the generator G through transformer T, in the secondary of which is placed a small resistor R_1 for obtaining a small voltage component proportional to current. A component proportional to voltage is fed to tube V_3, a phase inverter which supplies push-pull voltages to tubes V_4 and V_5.

Tubes V_3, V_4 and V_5 constitute a

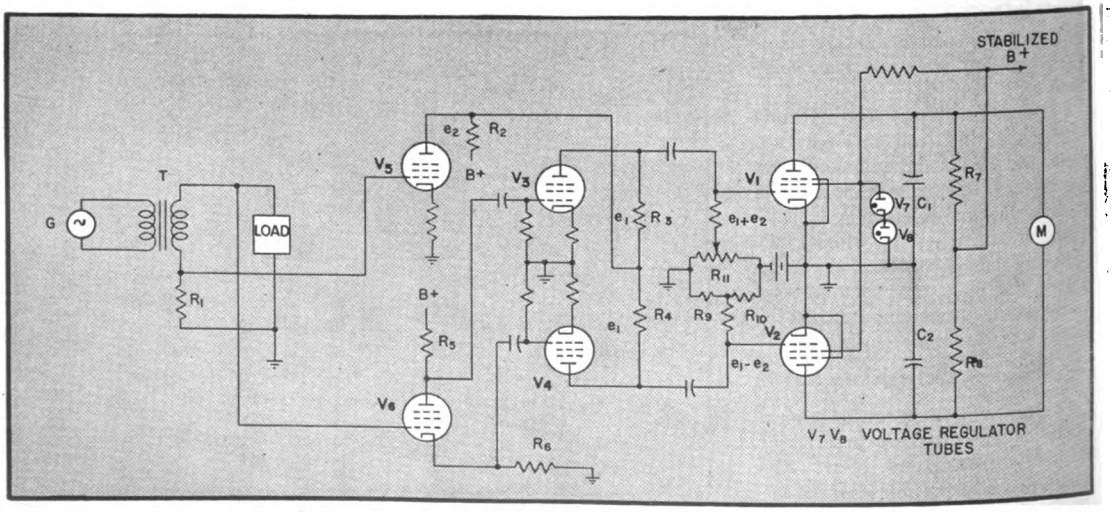

FIG. 3—Modernized electronic wattmeter makes use of cathode follower to shift phase of the potential component, and balanced modulator to combine current and potential for rectification by the parabolic rectifiers which feed the indicating meter

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mixer circuit which, by virtue of the particular plate connections employed and the relative phases of the plate currents, produces sum and difference voltages at the grids of pentode parabolic rectifiers V_1 and V_2 proportional to voltages at the input circuits of the mixer tubes.

This arrangement avoids the current and voltage transformers of Peterson, gives greater frequency range, and is readily adapted to single-ended circuit measurements. The advantages of using pentode rectifier tubes are brought out in the following paragraphs.

Parabolic Tube Characteristics

Considerable care is required in the selection and operating conditions of the tubes V_1 and V_2. For true parabolic operation the first derivative of the plate-current, grid-voltage curve should be a straight line. Thus the linearity of the transconductance versus grid-voltage curve should be used as a criterion of parabolic rectification characteristics.

The tube transconductance is given by $g_m = \partial i_p/\partial e_g$ so that $\partial^2 i_p/\partial e_g^2$ or $\partial g_m/\partial e_g$ should be linear to meet the above requirements. Typical curves of grid voltage versus transconductance for a typical screen-grid tube are given in Fig. 4.

It can be readily shown[2] that the steady or d-c value of the incremental plate current Δi_p of a parabolic plate rectifier due to the application of a superimposed a-c grid voltage ΔE_g is given by

$$\Delta i_p = \frac{1}{4}\frac{\partial g_m}{\partial e_g}(\Delta E_g)^2 \qquad (8)$$

where ΔE_g is the peak value of the applied a-c voltage. Equation (8) shows that the slope of the transconductance curve should be steep and that the linear portion should extend over the widest possible grid range for greatest change of plate current. High-conductance power tubes are thus indicated as suitable for parabolic rectifier applications and will give the greatest change of plate current.

The importance of Eq. (8) will be realized when power factor is taken into consideration. Assuming equal inputs to the rectifier tubes only one tenth the meter reading for unity power factor loads will be obtained for 0.1 power factor loads. While it would seem possible to increase meter sensitivity indefinitely to cover low power factor measurements, tube microphonics and d-c stability limitations militate against this alternative.

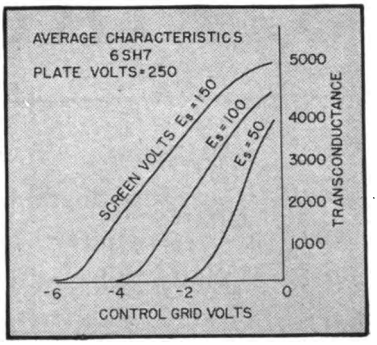

FIG. 4—Transconductance vs grid voltage for various values of screen voltage of a typical screen-grid tube

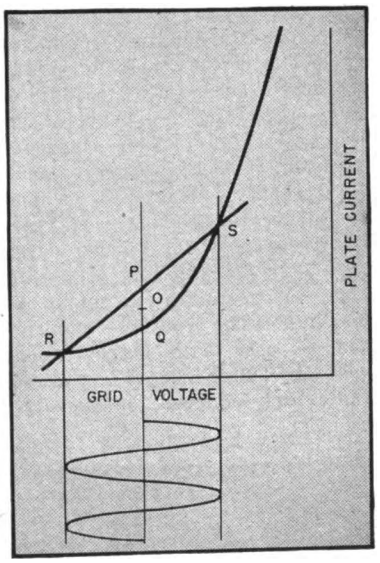

FIG. 5—Graphic method of determining the d-c change in plate current due to applied a-c grid potential

Incremental plate current may also be determined graphically. A straight line RS is drawn on the i_p/e_g characteristic, connecting the positive and negative peaks of the applied voltage on the parabolic working curve as in Fig. 5. A perpendicular PQ is then dropped to the working point Q of the curve. One half of the distance PQ, or OQ, is the incremental or d-c change in plate current for the given a-c wave applied.

Design Considerations

It is apparent that V_1 and V_2 should be matched both statically and parabolically. Feedback methods to stabilize these characteristics are difficult to apply and become complex due to the fact that the input and output components are totally different in character: that is, the input is an alternating current and the output is a d-c component produced by the non-linear characteristics of the tubes.

One good method of tube selection is to first choose tubes having similar but not necessarily identical static characteristics. By applying a small a-c voltage the tubes can then be selected for parabolic or rectification characteristics by noting d-c plate current changes.

Use of high-transconductance rectifier tubes with large grid swings gives considerable d-c plate and screen current variations. Voltage-stabilized sources thus become essential in order to preserve the linearity of the meter readings. The advantage of using pentode rectifiers is that plate current is substantially independent of plate voltage.

It would seem that unlimited sensitivity might be obtained by using high values of plate resistance R_r and R_s and a sensitive meter. However, the rectifier circuit and meter may be considered as a d-c amplifier and so to avoid microphonics and other circuit instabilities the overall d-c gain should be kept low. The bias arrangement shown in Fig. 3 enables residual unbalanced components to be eliminated from the meter circuit. Meter shunts can be used to extend the effective working range and to protect the instrument during the warm-up period provided care is taken not to use inputs that exceed the linear transconductance range of the rectifier tubes.

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INDUSTRIAL X-RAY

Survey of tubes used today in plants for microradiography with low-voltage beryllium-window types, x-ray diffraction with types having targets lower in atomic number than the material to be examined, and industrial radiography at 50,000 to 2,000,000 peak volts

INDUSTRIAL x-ray tubes have greatly increased in number and variety within the present war period. In fact, they have received from this war as great an impetus as that which marked medical x-ray tube development after World War I.

Although the first industrial x-ray installation in this country was completed in 1922, there was a long period when such tubes, in effect, took a back seat with respect to the developments in the field of medical applications. During this slow development period when the value of x-ray was being proven for industrial use, tubes designed solely for medical applications were commonly used. Aside from a few limitations, these tubes adequately met the industrial requirements of this period.

Within recent years the great increase in applications has brought about a demand for tubes designed specifically for industry. As a result, today there is available a complete range of industrial x-ray units employing tubes from the very low-voltage type to the super-voltage tubes of one and two-million volt capacity. A brief description of the various designs of tubes, divided primarily as to operating voltage and application, follows.

Low-Voltage Tubes for Microradiography

With the advent of beryllium-window, permanently-evacuated x-ray tubes,[1] developed primarily for diffraction, low-voltage radiography became a practical tool. This field covers radiography of thin sections that can be magnified to produce a microradiograph, and radiography of thin spot-weld structures such as airplane aluminum wing sections viewed directly or at low magnification.

Microradiographs can be successfully magnified to 200 to 400 diameters. The limiting factor, of course, is the film emulsion itself. Ordinary radiographic films are too grainy and only suitable for low magnifications up to 15 to 20 diameters. The first successful emulsion usable for this work was the Lippman emulsion, which essentially was a non-grain material. Within recent years the Eastman Kodak Co. has developed Type UO film and plate suitable for magnification up to 50 diameters. The type 548-0 emulsion can be used with magnifications well over 200. Figure 1 is a microradiograph enlarged 250 diameters

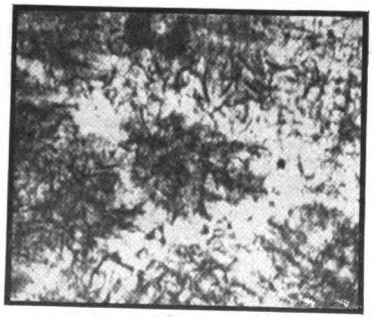

FIG. 1—Microradiograph, enlarged 250 times, of high-temperature cast iron alloy. The lighter areas are of higher x-ray density

of high-temperature cast iron alloy. Lighter areas are of higher x-ray density.

There are basically two different methods used in interpreting microradiographs. The most common method[2] is simply to use the differences in absorption of the various arrangements of crystals or elements in the thin section as exaggerated by long-wavelength x-rays. The second method[2] is based on characteristic absorption discontinuities of the various elements which compose the substance being radiographed.

Interpretation of Microradiographs

In the first method a tungsten target usually is desired because it gives the maximum intensity of radiation. For a given x-ray tube current the efficiency of total radiation produced is a linear function of the atomic number. Copper or other low-atomic-number targets are usable for this work, but the exposures required are about 2½ times as long as those for tungsten.

In the second method, characteristic radiation is required which makes possible the accentuation of the contrast to bring out small inclusions that might not otherwise be discernible. Going even farther, by proper selection of the target material with respect to the critical absorption coefficient of the suspected element the method can be used to determine an unknown. The target selection for this technique should be two or three atomic numbers higher in the periodic chart than the unknown being sought. This calls for considerable compromise and can become a real headache for the x-ray tube designer who is required to provide the necessary numerous target materials. For example, this method has been proposed to identify and locate the iodine secreted in a goiter. Iodine, having atomic number 53 with a critical absorption coefficient of 0.37344 angstrom units calls for lanthanum, 57, or cerium, 58, for a target. Since neither can be used in modern permanently

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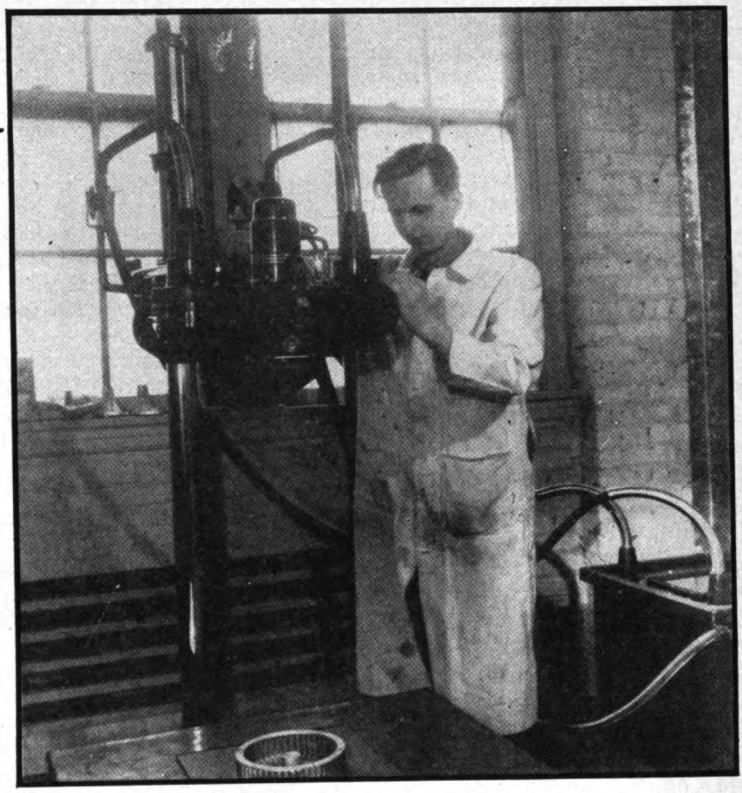
TUBES

By Z. J. ATLEE

Chief, Vacuum Tube Engineering Dept.
General Electric X-ray Corporation
Chicago, Illinois



Radiographing an aluminum casting with x-ray tube head employing the 140-kvp tube shown in Fig. 2D. Connections to the high-voltage transformer at the right are made with shockproof cable

evacuated tubes, a compromise would have to be made by going up to the first possible practical target above iodine in atomic number. This would be tantalum, 73.

Recently another technique made possible by these low-voltage tubes has been developed[4, 5]. This is chemical analysis by x-ray absorption using a comparative method. A phototube of the secondary electron multiplier type, a sensitive x-ray fluorescent screen to produce light of a wavelength to affect the phototube, and the low-voltage x-ray source are the essential parts of this system. The cell of unknown material can have a wide variety of shapes and include substances in all forms, as gases, liquids, or solids.

Figure 2A illustrates a beryllium-window tube for this class of work. It has a large-diameter beryllium window to give adequate coverage, and it can be operated at voltages from as low as one or two kvp (kilovolts peak) up to a maximum of 50 kvp oil-immersed. When oil-immersed the mounting is made in such a manner that there is no oil absorption, the beryllium being exposed directly to air.

Targets for X-ray Diffraction

Tubes for x-ray diffraction are essentially in the low-voltage classification described above and, as explained, preceded them in development. Here characteristic radiation is the sole interest. The total white radiation produced is a nuisance and many different mechanisms are employed to eliminate it. The operating voltage required ranges from 20 to 70 kilovolts, with most work done in the range of 25 to 42 kvp. The essential requirement in voltage is that it be above the minimum exact value that excites the characteristic radiation and not high enough to give so much white radiation that the characteristic lines are covered up.

Different wavelengths of radiation are required to provide suitable measuring sticks[6, 7] for the infinite variety of materials being studied by x-ray diffraction. This has meant a demand for targets of different atomic numbers, ranging from tungsten with an atomic number of 74 down to chromium with an atomic number of 24. This diversity has meant considerable work for the x-ray tube designer in that targets of metals such as cobalt, chromium, etc, have not been easily fabricated into the necessary target shapes and purity.

Chromium target tubes are being made today by electroplating onto the copper anode. Such electroplated targets also have the advantage of higher rating over a solid block type of target, being thin layers on the high-conductivity copper backing. Purity of metal in the target is important because impurities will give their characteristic radiation lines in the spectrum and thus confuse the interpretation of the diffraction pattern. It is possible for an impurity of as little as one part in ten thousand to give a line strong enough to result in misinterpretation under certain conditions. If it were not for the difficulty of making samples into targets for such an x-ray tube, this method could be used for chemical analysis. As a method, of course, it could not compete with spectroscopy either from a standpoint of sensitivity or convenience.

Beryllium-Window Tubes for Diffraction

An accepted type of tube for diffraction is of a two-port construction with beryllium windows as shown in Fig. 2B. This tube is made as a standard production item in seven different targets—tungsten, molybdenum, copper, nickel, cobalt, iron, and chromium. In addition, for special orders it has been

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supplied in silver, columbium, zirconium, germanium, manganese, and titanium. Vanadium has been requested and is definitely a desirable target material for some specific applications. Unfortunately, as yet the metal has resisted all attempts to make it into a successful target. Success with titanium has been very poor and only one or two experimental tubes have been made to date.

The demand is for long-wavelength radiations. The only way to accomplish this is with lower atomic number targets, and the question is just how far it is possible to go. With sealed-off types of tubes probably the lowest atomic number material in a commercial tube will be titanium, atomic number 22. Scandium, atomic number 21, is a rare earth unavailable as a target material except possibly for a research project.

Recent attempts to make a calcium (atomic number 20) target tube show that it will not be possible in a sealed-off commercial type of tube. An experimenter working with a demountable tube on continuous exhaust equipment could probably utilize it as a target. Below atomic number 20, the choice becomes slim indeed. Silicon, atomic number 14, would be the first possible choice. Its characteristic K alpha radiation is 7.111 angstroms, which would be absorbed completely in a beryllium window only a few mils thick. For such long wavelengths the target, specimen, and diffraction camera will all have to be housed in the same vacuum.

Recently x-ray diffraction has been greatly enhanced by the successful development of a Geiger-counter type of continuous recording spectrometer.[8] It can be predicted that this type of unit will branch out into several different forms requiring specific tube designs to meet the equipment design.

Radiographic Low-Voltage Tubes

X-ray tubes for industrial radiography at voltages from 50 to 150 kvp have not received too much special attention from the designer. In general, tubes used in medical roentgenography and therapy have been employed with little modification. This has been particularly true for voltages up to 100 kvp which is today the maximum for medical roentgenography. Every tube manufacturer has a dozen or more types of tubes suitable for the application. Small self-contained, self-rectified units are available in many forms. In general they are all that is required for low-voltage industrial radiography.

Figure 2C shows a small self-rectified tube with 85 kvp top kilovoltage rating and 15 to 25 ma current rating, with a 1.7-mm line focus. This tube meets all of the present requirements for voltages of this order. Higher-current diagnostic tubes have never been used industrially since there has been no need to make fractional-second exposures. In the medical field, motion of the patient has required split-second speed in the radiograph to arrest motion—the same reason high-speed exposures are required in photography. This has brought about high-current tubes with small focal spots, as ideally accomplished in the rotating-anode tubes which are now in widespread use by the roentgenologist.

Rotating-Anode Tubes

Rotating-anode tubes are not used industrially today. It is very unlikely that any use will be found for the present type of rotating-anode tube other than in medical work. Incorporation of rotating anodes in high-voltage x-ray tubes to provide for small focal spots is a possibility, but at present it does not seem to go beyond being just that.

In the diffraction field, rotating-anode types of tubes may some day be a reality because small focal spot loadings are limited even with circulating coolant, particularly with targets of low melting point and poor conductivity. Diffraction tubes require continuous loadings, making the present form of medical rotating anode of no particular value. The tube will probably have to be operated on the vacuum pump and have a relatively tight vacuum bushing to be able to bring circulating coolant to the anode. A tube of this type was made quite some years ago by Mueller in England.[9] Rcently a rotating-anode diffraction tube has been described by McArthur, University of Leeds, England.[10] A mercury-oil liquid seal is described, credited to Astbury, operating at the relatively low speed of 620 rpm.

Recently a rotating-anode seal has been made with a metal-oil sealing surface that has operated satisfactorily at 3000 rpm.

Tubes for 100 to 150 Kilovolts

Above 100 kilovolts, the present ceiling for medical roentgenography, we begin to arrive at operating requirements in industry that made necessary the design of tubes specifically for industrial use. However, up until recent years the range of voltage from 100 to 150 kv has been handled industrially by the medical superficial therapy class of tube. Tubes in this range have been essentially of low-voltage design, with sufficient increase in dimensions to operate 50 kv higher. Essentially continuous loadings are required at low currents of five to 10 ma. In general, these tubes are made in shockproof casings with high-voltage cables to the generator as used for low-voltage tubes. The casing and tube are cooled by tap water, oil cooler, or fans. One of the tubes used in a shockproof casing for 140-kv industrial equipment is shown in Fig. 2D. A similar design of equipment has been made for voltages as high as 220 kvp, but this is the maximum because of the cables.

High-Voltage Tubes

Above 150 kilovolts we enter the higher-voltage range which is usually thought to start at 200 kilovolts. As pointed out in the beginning, this is the start of the deep-therapy range for which a well-developed commercial line of tubes has been available for many years. These tubes met the industrial requirements in all but one very important consideration—that of focal spot size. In therapy work a beam of radiation bathes the patient just as it would for ultraviolet treatment, so the source of medical

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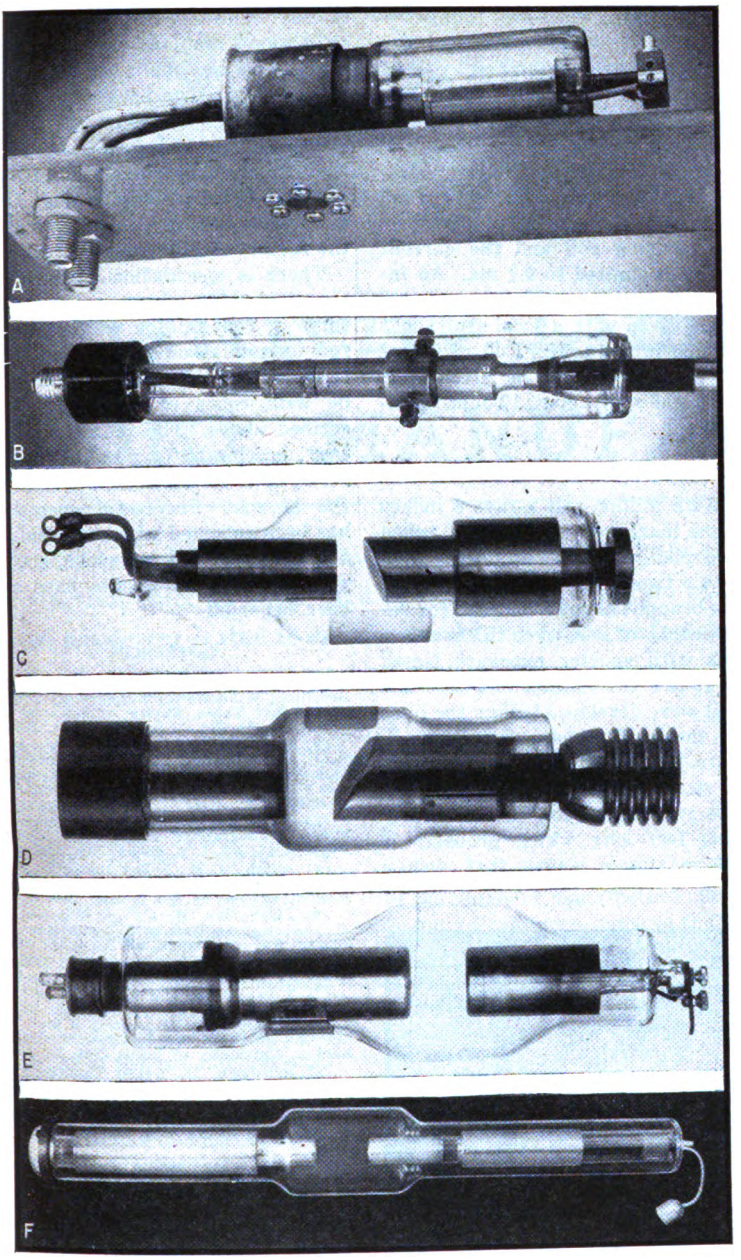

FIG. 2—Examples of modern industrial x-ray tubes. (A) Tungsten-target diffraction tube with ¾-inch beryllium window; (B) Two-port beryllium-window diffraction tube, in which the ports resemble black buttons fused into the glass envelope; (C) Small self-rectified tube for 85-kvp operation; (D) X-ray tube used in 140-kvp oil-immersed head; (E) Self-rectified hooded-anode line-focus tube for 250-kvp operation; (F) X-ray tube used in 400-kvp unit for self-rectified operation now made only with line focus but with five types of fittings

radiation need not be small. For shadow-pictures, ports and cones which limit the radiation to the area being treated are not required. Of course, for industrial radiography it is desirable to approach a point source as far as practical, to get the desired detail.

The therapy tubes with large round or elliptical focal spots 10 to 20 mm in diameter were used in the early days of industrial radiography and were at best only a poor compromise. By working at long distances, of course, they did give satisfactory radiographs. Gradually the size of therapy-tube focal spots was brought down to 8 to 10 mm diameter to help in radiography.

It has been only within the last five years that line focus tubes with 5-mm projected focal spots and 20-degree targets have been made available for exclusive use in industrial radiography. Some sacrifice in the therapy tube life was made by attempting to reduce the focal spot size so that they are now made in the former 20-mm size of spot. Figure 2E shows the modern self-rectified 250-kilovolt tube with oil circulation and hooded anode construction. This same tube is made with two different focal spots, 20-mm round focus for therapy with 250 kvp and 15 ma continuous rating, and 5-mm line focus with 250 kvp and 10 ma intermittent-duty rating compatible with the radiographic exposure times needed.

400-Kilovolt Tube

Above 250 kvp various models of tubes have been made for 300 kilovolts and higher because of the industrial demand for radiographing greater thickness of steel.[11] These models were made obsolete by the successful development of a 400-kilovolt tube[12] for such use that has had a very wonderful record in medical therapy and industrial radiography since 1935. At first it was energized from various forms of generators to give a constant or unipotential voltage. The tube was housed in a separate oil tank or an air drum, or in some cases in the same cumbersome tank with the high-voltage generator and kenotrons. In 1939 it was redesigned to operate self-rectified, making possible a practical single-package high-voltage x-ray unit.

At first this tube was made only with round focus for both medical and industrial applications. As the industrial demand exceeded the

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medical it was redesigned in line focus and is today made only in line focus for all applications. This is possible because the rating has been limited to 5.0 ma at 400 kvp for all types of generators. Today this one tube is supplied with five different types of fittings to operate in the obsolete type of generators as well as the self-contained, self-rectified unit of present manufacture. This tube, as shown in Fig. 2F, was for a number of years, and until the advent of the present million-volt tube, the largest and highest-voltage permanently-evacuated x-ray tube made.

No commercial permanently-evacuated x-ray tubes have as yet been made for voltages between 400 and the now well established million-volt type of tube. Before and throughout the period when the 400 kvp tube was the highest voltage type available, various therapy installations were made for voltages from 600 to 1000 kvp and higher, with demountable tubes operated on the exhaust system continuously.[13] It is significant that none of these installations was made for industrial radiography. The reason is quite apparent when you consider their size and lack of mobility.

The first million-volt industrial installation was made using the type of unit developed in the General Electric Research Laboratory for medical therapy[14] but with the pumping equipment mounted on the tank to give some small degree of mobility. It operated successfully until the development of the present unit incorporating the sealed-off type of tube. As a matter of fact, the physical dimensions of the demountable tube were made so closely approaching the present sealed-off type that it had little to offer in ruggedness over the present tube.

Million-Volt X-ray Tubes

The tube for million-volt industrial radiography is an eleven-section tube operated self-rectified inside a 180-cycle resonant transformer, with freon gas as the dielectric.[15] Nearly fifty of these tubes are in operation daily in industrial installations, and they are making important contributions to the war effort. Only one unit of this type is in use medically, at Walter Reed Hospital in Washington, D. C.

The SMS-1000 tube (abbreviation of Sealed-off Multi-section 1000 kvp) has a round focal spot of three different values depending on the operating current. For best possible radiographic detail where a great distance cannot be employed, the focal spot is focused to a small spot about 5.0 mm in diameter by the focusing coil and the current rating is limited to 0.1 ma. An intermediate current rating of 1.0 ma is given with a focal spot about 7.0 mm in diameter. Full rating of 3.0 ma at 1000 kvp is given with the focal spot about 10 mm in diameter.

Two-Million-Volt Tube

With million-volt x-rays 8 inches is the maximum thickness of rolled steel plate that can be radiographed with a two-hour exposure. The war has brought about a demand for radiography of steel even thicker than this with shorter exposure times. In 1944 a two-million-volt tube and unit were developed[16] along the lines of the million-volt equipment illustrated. Figure 3 gives the physical size comparison of the two tubes. The two-million-volt tube is nearly nine feet long which probably is the maximum length that such a tube will ever reach. Possibly three- or four-million-volt tubes will be built along similar lines, but they will not be any picnic for the x-ray tube builder. The present two-million-volt tube in the horizontal position, supported by the anode, deflects more than ⅛ inch at the cathode end. Special carrying trays had to be made to carry the tube around the factory during construction.

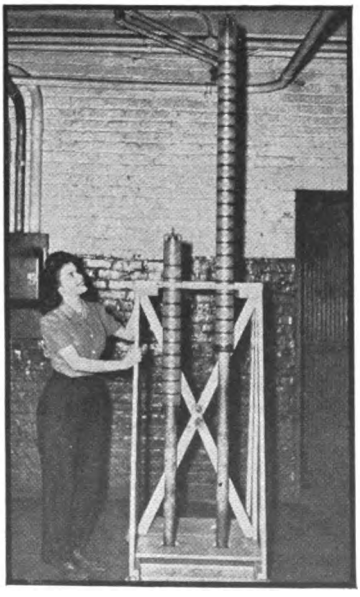

FIG. 3—Comparison of 1,000,000 (left) and 2,000,000 (right) kvp industrial x-ray tubes

There is speculation as to what the next step above voltages of three or four-million will be either for industrial or medical applications. It is certain that it will not be with tubes of the design described above. The induction electron accelerator[17], now popularly referred to as the betatron, may be the answer. Successful operation has been reported with such devices at from 20 to 100 megavolts, but as yet radiographic results have not been reported.

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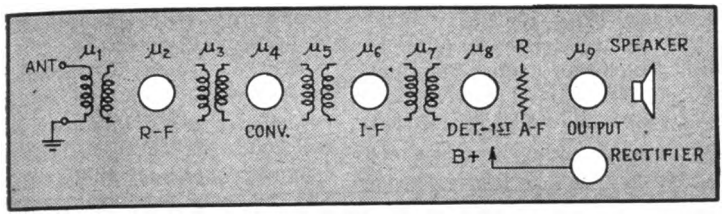

FIG. 1—Simplified diagram of six-tube receiver used as example in illustrating procedure for setting sensitivity control limits for production-line tests

Sensitivity Limits in RADIO MANUFACTURING

Statistical procedure for determining economical sensitivity limits of receivers coming off a production line, and use of a preselected average set of tubes to determine if rejection of a receiver is due to circuit trouble or to an unfortunate combination of tubes

By A. S. BLATTERMAN
Manufacturing Methods Division
RCA Victor Co. Limited
Montreal, Canada

EVEN with the most careful control in manufacture the performance of finished radio receivers of a given design will vary. The performance can be described in terms of various operating characteristics such as the selectivity, sensitivity, maximum power output, avc action, and distortion (using the terms in a very general sense). These characteristics are not independent of one another, nor are they all of the same importance.

The present discussion directs attention to the sensitivity alone, defining it in terms of microvolts input to give a stated output (in watts or in volts). The sensitivity will vary from one receiver to another, and the question arises as to how much variation should be expected or allowed. This question can be answered through straightforward statistical analysis.

Suppose we consider a more or less conventional six-tube receiver as indicated in Fig. 1. Here there are at least eleven variable factors in the circuit which will affect the overall sensitivity—the nine gain factors $\mu_1, \mu_2, \mu_3, \ldots \mu_9$ of the coupling circuits and tubes, the coupling resistor R, and the B supply voltage.

In the course of manufacture and assembly of receivers, suppose that each of the above eleven factors varies ± 10 percent. The total overall gain of the receiver (its sensitivity) might then, if we happen to get all low-value factors together first and all high-values factors next, vary in the ratio of $(1.1/0.9)^{11}$ and give a range of over 9 to 1 in sensitivity.

Standard Deviation Unit

It will now be shown that the principle just used, taking all the possible maximum and minimum limits for determining the limits of a complete assembly of parts, is not economically justified. It will also be shown how proper economic limits may be specified.

If the gain factor (the mutual conductance g_m) of a large number of supposedly identical vacuum tubes is measured, it will be found that there is a certain distribution of high, low, and intermediate values. Under commonly existing, controlled conditions of manufacture, the distribution will follow the normal or Gaussian law typified by the curve of Fig. 2. About 68 percent of all values of g_m will be within ± 1 standard deviation s from the average value, about 95 percent within ± 2 standard deviations $2s$, and 99.73 percent within ± 3 standard deviations $3s$ from the average.

The standard deviation s is a statistical measure of dispersion and by formula is the square root of the average of the squared differences from the arithmetic mean

$$s = \sqrt{\frac{(X_1-\overline{X})^2+(X_2-\overline{X})^2+\ldots.(X_n-\overline{X})^2}{n}} \qquad (1)$$

where n is the number of observations and $\overline{X}$ is the arithmetic mean of the n observations. The same sort of thing will happen for such other circuit elements as coils, resistors and capacitors if measurements are made of Q, R, or C.

Tube-Picking Probabilities

To go back to the vacuum tubes, suppose the average mutual conductance value of a certain kind of tube is specified as 1,000 micro-

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mhos. If a lot of say 100 of these tubes is measured, it will be found that the average value is very closely 1,000 micromhos. The standard deviation s, when calculated, may be 10 micromhos. This means then that if we pick out tubes at random from a large lot we can be quite sure of not getting more than about 15 in 10,000 tubes having g_m greater than $1{,}000 + 3s = 1030$ micromhos, and no more than 15 in 10,000 with g_m less than 970 micromhos.

With this low probability of picking a tube having either extremely high or extremely low gain, the chances of ever getting a combination of say 5 such tubes into one receiver, all having highest gain or all having lowest gain in a given combination, is exceedingly remote indeed. The fallacy of setting performance limits of the assembled receiver on the basis of separately adding maximum and minimum limits of component parts is therefore obvious. One would expect almost all receivers to give performance very far within the extreme limits that such a calculation shows.

Suppose that coils, transformers, resistors, voltages, etc are held substantially constant so that receiver sensitivity is only affected by the tubes, and suppose there are n stages of these producing average stage gains of $\mu_1, \mu_2, \mu_3, \ldots \mu_n$ decibels with standard deviations of gain from each of the average values of $s_1, s_2, s_3, \ldots s_n$ decibels. Then for the combination of n tubes the value of average overall gain is

$$\bar{\mu} = \bar{\mu}_1 + \bar{\mu}_2 + \bar{\mu}_3 \ldots\ldots\ldots + \bar{\mu}_n \text{ db} \quad (2)$$

and the standard deviation of this overall gain is

$$s_\mu = \sqrt{s_1^2 + s_2^2 + s_3^2 + \ldots\ldots\ldots s_n^2} \text{ db} \quad (3)$$

The limits, then, of overall gain $\bar{\mu}$ between which we may expect to find all receivers except about 3 in 1000 are $\bar{\mu} + 3s_\mu$ and $\bar{\mu} - 3s_\mu$.

Equations for Equal Stage Gains

As a simple special case to illustrate the point of the discussion let us suppose that the individual stage gains (average) are all the same (μ_1) and that each has the same standard deviation s_1. Then Eq. (3) becomes $s_\mu = s_1\sqrt{n}$, and 99.73 percent of all receivers will show gains between the limit values $n\,\bar{\mu}_1 + 3s_1\sqrt{n}$, and $n\,\bar{u}_1 - 3s_1\sqrt{n}$.

Had we followed the plan described earlier of finding these limits from the $3s$ limits of each stage, the overall limit values would obviously have been $n\,\bar{\mu}_1 + 3s_1 n$ and $n\,\bar{\mu}_1 - 3s_1 n$, which is a variation from overall average gain $\sqrt{n}$ times as great. The extreme case where all tubes are on the low side or all on the high side may of course happen, but the point is that the probability of it happening is extremely small. The situation is shown in Fig. 3 for four stages ($n = 4$).

Practical Application

An important practical question that arises is, "In the quantity production of radio receivers of a given type, what high and low limits shall be established for sensitivity such that within these limits we can be sure that variations in sensitivity are due solely to normal variations in tubes?" The procedure is as follows:

(1) Select a receiver of the type to be dealt with which is known to be normal (although perhaps not exactly average) in regard to its component parts, wiring, etc., and allow it to come up to operating temperature with a random lot of proper type tubes in the sockets.

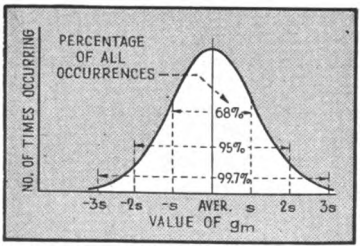

FIG. 2—Variations in mutual conductance values of supposedly identical tubes follow the normal or Gaussian distribution curve shown here

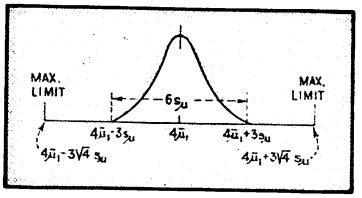

FIG. 3—Variation in overall sensitivity of four stages having equal gain. The maximum limit is twice the probable limit for four stages

(2) Take successive readings of sensitivity (μv input for standard output) for say 100 different tubes inserted in socket No. 1. These, for example, could be 100 different type 6K7 r-f amplifier tubes taken at random from stock.

(3) Calculate the average sensitivity $\overline{X}_1$ (μv) of the 100 readings and the standard deviation s_1 in μv.

(4) Insert in socket No. 1 a tube which produces this average value of sensitivity, and leave it there.

(5) Take successive readings of overall sensitivity for 100 different tubes of the required type, inserted one after the other in socket No. 2. Again calculate average value of sensitivity $\overline{X}_2$ of these 100 readings and the new standard deviation s_2.

(6) Insert in socket No. 2 a tube which gives this average overall receiver sensitivity, and leave it there.

(7) Repeat for each successive socket until all sockets are equipped with average tubes.

(8) Measure sensitivity $\overline{X}_n$ (microvolts) of the receiver with the tubes in the sockets which have thus been selected as being average tubes.

(9) Calculate the expected standard deviation in sensitivity s_t of the receiver with randomly chosen tubes in production from

$$s_t = \overline{X}_n\sqrt{(s_1/\overline{X}_1)^2 + (s_2/\overline{X}_2)^2 + \ldots (s_n/\overline{X}_n)^2}$$

(10) Set sensitivity limits for normal tube variations at $\overline{X}_n + 3s_t$ and $X_n - 3s_t$ μv.

Six-Tube Set As Example

Suppose that sensitivity limits are required for a six-tube set with the following tube complement: (1) r-f amplifier; (2) converter; (3) i-f amplifier; (4) detector—first audio; (5) output; (6) rectifier.

As the first step in the procedure, sensitivity is measured in microvolts at the antenna and ground input terminals, using 100 tubes in each socket in turn. The complete data and calculations (hypothetical) for the r-f amplifier stage are given at A in Table I. Similar measurements are then made and tabu-

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TABLE I. DETERMINATION OF CONTROL LIMITS FOR SIX-TUBE SUPERHETERODYNE RECEIVER

(A) DATA FOR R-F STAGE (r-f tube changed 100 times—other tubes fixed)

X in μv	f freq. of occurrence	fX	$(X-\overline{X})$	$(X-\overline{X})^2$	$f(X-\overline{X})^2$
9.9	2	19.8	−0.4	0.16	0.32
10.0	4	40.0	−0.3	0.09	0.36
10.1	7	70.7	−0.2	0.04	0.28
10.2	20	200.4	−0.1	0.01	0.20
10.3	34	350.2	0	0	0
10.4	19	197.6	0.1	0.01	0.19
10.5	8	84.0	0.2	0.04	0.32
10.6	3	31.8	0.3	0.09	0.27
10.7	2	21.4	0.4	0.16	0.32
10.8	1	10.8	0.5	0.25	0.25
Total	100	1026.7			2.51

Av. $\overline{X}_1 = 1026.7/100 = 10.3$, and standard deviation $s_1 = \sqrt{2.51/100} = 0.159$

(B) AVERAGE VALUE OF MICROVOLTS INPUT $\overline{X}_1$ AND STANDARD DEVIATION s_n FOR STANDARD OUTPUT

Tube Disposition	No. 1 varied; 2, 3, 4, 5, 6 fixed	No. 2 varied; No. 1 at average	No. 3 varied; 1, 2 average	No. 4 varied; 1, 2, 3 average	No. 5 varied; 1, 2, 3, 4 average	No. 6 varied; others average
Averages $\overline{X}_{1, 2, 3 \ldots n}$	10.3	18.5	14.6	16.0	12.1	14.3
Std. Dev. $s_{1, 2, 3 \ldots n}$	0.159	0.304	0.180	0.215	0.120	0.106

(C) COMPUTATION OF CONTROL LIMITS FOR INPUT TERMINALS

Average overall sensitivity $\overline{X}_n = 14.3$ microvolts (measured with average tubes)

Overall standard deviation $s_t = 14.3 \sqrt{\left(\frac{0.159}{10.3}\right)^2 + \left(\frac{0.304}{18.5}\right)^2 + \left(\frac{0.180}{14.6}\right)^2 + \left(\frac{0.215}{16.0}\right)^2 + \left(\frac{0.120}{12.1}\right)^2 + \left(\frac{0.106}{14.3}\right)^2} = 0.45 \mu v$

Control limits on this receiver: $\overline{X}_n \pm 3s_t = 14.3 + 1.35 = 15.7$ μv and $14.3 - 1.35 = 12.9 \mu v$

lated for the other five stages, the results summarized as at B in Table I, and the control limits computed as at C.

The data in Table I also provides another check. It is common practice to measure the sensitivity at the control grid of the converter tube. We have, from the data, the standard deviations for the groups of 5 tubes (r-f tube eliminated): $s_2 = 0.304$ μv; $s_3 = 0.180$ μv; $s_4 = 0.215$ μv; $s_5 = 0.120$ μv; $s_6 = 0.106$ μv. Suppose the sensitivity at the converter grid with average tubes is 170 microvolts. This gives for the combination

$$s_0 = 170 \sqrt{\left(\frac{0.304}{18.5}\right)^2 + \left(\frac{0.180}{14.6}\right)^2 + \left(\frac{0.215}{16.0}\right)^2 + \left(\frac{0.120}{12.1}\right)^2 + \left(\frac{0.106}{14.3}\right)^2} = 4.67 \mu v$$

Therefore the sensitivity limits at the converter grid to be taken as acceptable and due to normal tube variations in this particular receiver are $170 + 3s_0 = 184.0$ μv and $170 - 3s_0 = 156.0$ μv.

Sensitivity Deviations Not Due to Normal Tube Variations

We can go farther now and establish economic sensitivity limits where the variations are due to the combined effect of normal variations in coils, capacitors, resistors, wiring, etc. The procedure is as follows:

Using a set of average tubes determined as such by the measurements and calculations previously described, measure the sensitivity of say 100 different receivers each of which is known to have normally controlled components. Since the same tubes are used in each of the sets, variations in sensitivity between the sets will be due solely to variations in the sets themselves.

Calculate the average sensitivity $\overline{X}_s$ in microvolts for the lot of sets used and the standard deviation S_s of the sets in microvolts. If in production average tubes are used, the acceptable limits in sensitivity for set variations alone will be $\overline{X}_s + 3S_s$ and $\overline{X}_s - 3S_s$. If, on the other hand, tubes are taken at random, the limits in sensitivity covering normal expected variations of both tubes and sets will be

$$\overline{X}_s \pm 3\overline{X}_s \sqrt{(s_1/\overline{X}_1)^2 + (s_2/\overline{X}_2)^2 + \ldots\ldots (s_n/\overline{X}_n)^2 + (S_s/\overline{X}_s)^2}$$

Having established sensitivity limits as described, a production receiver showing sensitivity beyond these limits must be immediately suspected as containing abnormal components or wiring or abnormal tubes. Insertion of a set of average tubes removes the possibility of abnormal tubes and if the sensitivity then exceeds $\overline{X}_s \pm 3S_s$ microvolts, the set must be suspected of abnormality in itself.

Trouble Shooting

Sensitivity values as measured on 100 receivers coming from production, each using the set of average tubes measured in the first example, are $\overline{X}_s = 13.5$ μv and $S_s = 0.50$ μv. Limits on sensitivity exclusive of tubes are $13.5 \pm 3 \times 0.5 = 12.0$ to 15.0 μv. Limits including both normal tube and set variations are

$$13.5 + 3 \times 13.5 \sqrt{\left(\frac{0.159}{10.3}\right)^2 + \left(\frac{0.304}{18.5}\right)^2 + \left(\frac{0.180}{14.6}\right)^2 + \left(\frac{0.215}{16.0}\right)^2 + \left(\frac{0.130}{12.1}\right)^2 + \left(\frac{0.106}{14.3}\right)^2 + \left(\frac{0.50}{13.5}\right)^2} = 15.7 \text{ to } 11.3 \mu v$$

Limits including tube variations only (see previous example) are

$$13.5 \pm 3 \times \frac{13.5}{14.3} \times 0.45 = 14.8 \text{ to } 12.2 \mu v$$

Suppose now that a receiver comes through production with random tubes and shows a sensitivity of 16.0 μv. This is beyond the upper limit of 15.7 μv. Upon the insertion of a set of average tubes (selected as previously described), the sensitivity is 14.2 μv. This is within the 12.0–15.0 μv limit for receiver variations alone. We conclude that there was trouble with the original set of tubes.

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WOOFER-TWEETER

Design and construction of a crossover network for feeding a low-frequency horn and a high-frequency horn from a single amplifier, using low-cost components yet giving a response flat within 2 db from 30 to 10,000 cps, with crossover at 400 cps

By PAUL W. KLIPSCH
Hope, Arkansas

IN some experimental work involving two speakers, a crossover network was evolved which gives very flat overall performance over a wide frequency range but which involves low-cost components. The crossover network itself follows ordinary design and may be altered to conform to derived m, x-termination, or other configuration. The use of non-high-fidelity components to give high-fidelity performance is the point of novelty. Since many questions have been asked about the network it was felt that a description of the whole circuit, including the design steps, would be of interest.

The Circuit

Figure 1A shows the circuit as actually set up. Each output transformer is required to work over only a narrow frequency range so that inexpensive components are used in place of high-fidelity units. Placing the network reactances in the high-impedance part of the circuit results in small capacitor values of much lower cost than the, say, 100-microfarad capacitors which would be required if placed in the 8 to 16-ohm part of the circuit.

Design of Network

The transformer requirements are dependent upon the design of the network, so their consideration will be dealt with as part of the design.

Figure 1B shows the basis of the design, a ½-section low-pass portion to allocate the low-frequency output to the appropriate load, and a 1½-section high-pass portion to feed the high-frequency load. The choice of the number of sections is based on the fact that a steep cutoff for the low-pass portion is not necessary as most low-frequency loudspeakers will cut off somewhere near the crossover frequency. The high-frequency speakers, when fed power at frequencies below their acoustic cutoff, are very apt to radiate harmonics of the received power,[1] and since harmonics constitute one form of distortion, this is to be avoided. Thus a steeper cutoff is provided in the high-pass filter by the choice of 1½ sections. Ideally, the ½-section low-pass portion would produce 12 db loss per octave above cutoff, and the 1½-section high-pass portion would give 30 db loss per octave below cutoff; practically, the loss is somewhat less due to the fact that the reactive elements will not exhibit zero power factor.

Design Equations

The numerical design follows conventional practice.[2] The impedance level was chosen as 5000 ohms, the nominal load for a pair of type 2A3 tubes operated self bias. The class A triode was chosen because of its inherently low distortion; with pentode or beam tubes it is imperative that feedback be employed to minimize distortion within the amplifier as well as to produce a low equivalent generator impedance to prevent distortion from being produced by the speakers. The cutoff frequency f was chosen as 400 cycles. The half-section low-pass portion requires elements

$$L_k = \frac{5000}{\pi f} = 4.0 \text{ henrys}$$

$$C_k = \frac{1}{5000\pi f} = 0.16 \text{ microfarad}$$

The isolated half-section causes a nominal loss of 12 db per octave, with the intercept of the zero loss line and the asymptote of 12 db per octave slope occurring at 1.41 times the nominal cutoff frequency. This intercept may be moved down to the cutoff frequency by doubling L, C, or the LC product.

In a conventional half-section, the capacitance would be $\frac{1}{2}C_k$. This was doubled, to make $C_1 = C_k$ so as to give 3 db loss at the nominal cutoff frequency and the desired slope beyond cutoff. Hence, in the figures C_1 is twice the computed value, so that in Fig. 1B $L_1 = \frac{1}{2}L_k = 2.0$ henrys, $C_1 = C_k = 0.16$ microfarad, and in Fig. 1A $L_1 = \frac{1}{2}L_k = 2.0$ henrys reckoned with the 2 windings connected series aiding and $2C_1 = 0.32$, two of which in series gives the equivalent $C_1 = 0.16$. This arbitrary change does not appear to have caused any undue variation in the input impedance.

The high-pass portion is calculated from

$L_k = 5000/4\pi f = 1.0$ henry
$C_k = 1/(5000 \times 4\pi f) = 0.040\ \mu f$

The configuration calls for architrave capacitors of $2C_k = 0.080$ and pillar inductances of $L_k = 1$ for the full-section and $2C_k$ and $2L_k$ for the following half-section. Thus $C_2 = C_k$. The inductance $L_2 = L_k = 1.0$, and T_2 has a primary inductance $L_T = 2L_2 = 2.0$.

Construction Details

The inductance L_1 should be wound with the windings closely coupled to enforce balance; it has been found satisfactory to put one winding on top of the other. Both

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CROSSOVER NETWORK

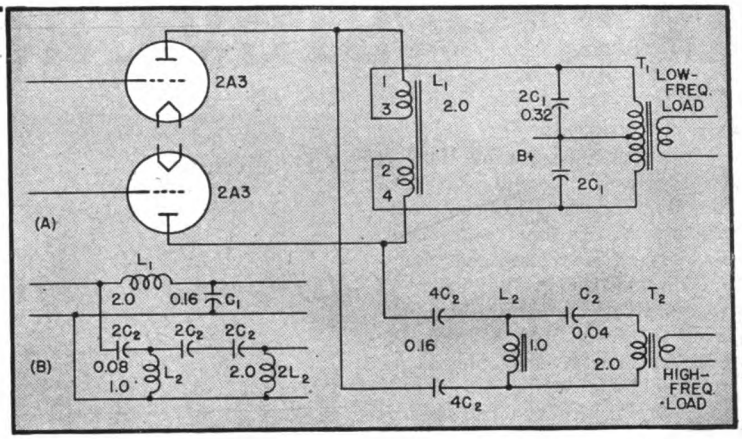

FIG. 1—Actual circuit of crossover network (A), and elementary circuit (B) used for design purposes

L_1 and L_2 should have adequate iron and copper to permit opening up a large air gap to hold the inductances reasonably constant at all levels of a-c voltage under which they will be required to operate. The matching transformer T_3 can be any readily available transformer of proper ratio which will give the required 2 henrys inductance when the air gap is opened up sufficiently to hold the inductance nearly constant over all levels of excitation.

Transformer T_1 should have a high primary inductance, of the order of 50 to 100 henrys to keep the exciting current low at the lowest frequencies to be transmitted, but its leakage inductance need not be held as low as demanded by expensive high-fidelity equipment; the leakage inductance as measured at the primary can be as high as one henry. Transformer T_2 must have a low leakage, preferable less than 0.05 henry to hold the loss at 10 kc to less than 3 db. It may be a low-cost unit, however, since its primary inductance need be only 2 henrys after opening the air gap—say 10 henrys before adding the air gap. Transformers T_1 and T_2 should have the proper turns ratios to match the 5000-ohm filters to the respective loads.

Collecting and tabulating the constants for Fig. 1A gives

Impedance level.....5000 ohms
Crossover frequency.....400 cycles
Inductance L_1.....2.0 henrys (series aiding)
Inductance T_1....50 henrys minimum
Inductance L_2.....1.0 henry (with air gap)
Inductance T_2....2.0 henrys (with air gap)
Capacitance C_1 .....0.16 microfarad
or $2C_1$ .....0.32 microfarad
Capacitance C_2 .....0.04 microfarad
or $4C_2$ .....0.16 microfarad
Leakage ind. of T_1.not over 1.0 henry
Leakage ind. of T_2.not over 0.05 henry

Conversion of the constants given for other impedance levels and/or other crossover frequencies is well known and will not be discussed.

The fact that a pair of 2A3 or 6A5G tubes exhibits a plate impedance of only 2000 ohms when the load impedance and the surge impedance of the filters are 5000 ohms raises the question of reflections. The mismatch is not great enough to cause serious reflection from a theoretical standpoint. A measured performance curve shows each output to be flat in its transmission range and to fall off smoothly in its attenuation range. The mismatch is necessary for proper loading of the output tubes and if this is a necessary evil from the filter standpoint it is of sufficient unimportance in the present application to be disregarded. It should be remembered that speaker voice-coil impedance is itself highly variable.

Performance

This crossover network has been in experimental use with a speaker combination comprising a low-frequency horn[3] operating between 40 and 400 cycles and a high-frequency horn operating from 400 cycles up. Two types of low-frequency horns and three types of high-frequency horns, all of different acoustic length, have been tried in various combinations. The output appears smooth throughout the transmission range including that in the immediate vicinity of crossover. Phase relations at this point seem to have little or no bearing on performance. Even complete 180-degree reversal of one speaker (in any of the several combinations) makes no difference in performance. Thus phase shifts in the described crossover network or in the speakers themselves may be neglected. Of course, if two identical speakers are used on one channel, they should be properly phased to prevent peculiar radiation patterns.

An obvious advantage of this crossover network is the fact that low-cost components may be used to give the same high-fidelity performance as more expensive equipment. The experimental model was constructed at less cost than that of a single high-fidelity matching transformer, and the performance is such that the combined power output is flat within 2 db from less than 30 cycles to over 10,000 cycles.

The design presented here may be considered the result of developing a pilot model. It is felt that the arrangement will be found advantageous for quantity production in connection with multiple speakers applied to home radios or for more specialized uses.

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Manufacture of SILVERED MICA

Discussion of mica quality factors, and details of new manufacturing techniques developed to conserve existing stocks of mica and at the same time improve tolerances and quality standards of finished units

By ALAN T. CHAPMAN

Engineer
Western Electric Co.
Kearny, N. J.

ALTHOUGH in peacetime there is a steady demand for mica capacitors required for radio sets and communications equipment, this demand was increased manyfold in wartime. The intrinsic properties of high stability, low-power factor or high *Q* high dielectric strength, low temperature coefficient and compactness possessed by mica capacitors make them practically indispensable in the design of electronic and communications equipment.

To increase the output of capacitors it might be assumed that the mica capacitor industry had but one current major problem, namely the one of increasing plant facilities and procuring additional manpower. However, there have been other problems of equal difficulty, such as critical shortages of mica and tinfoil, which have frequently compelled the mica capacitor manufacturer to produce on a day-to-day basis. Also, improvements in design and manufacturing methods were necessary to meet the exacting requirements under wartime operating conditions.

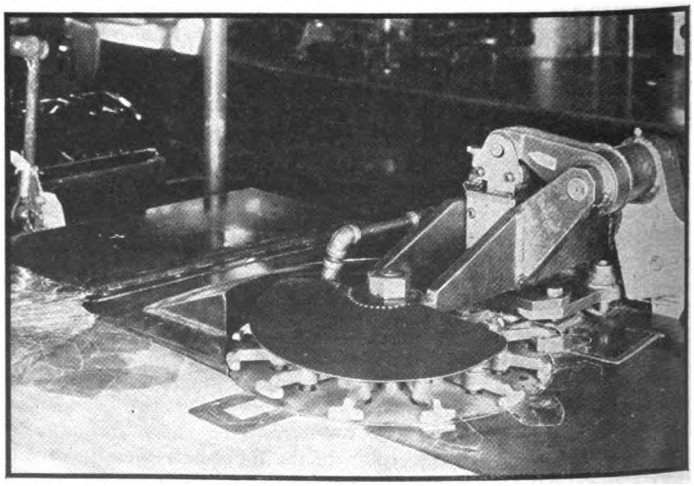
It is the purpose of this article to point out briefly the results of the Western Electric Company's efforts to surmount these difficulties, with the thought that part of the information presented may be helpful to other readers. It is appreciated that some of the results presented here were arrived at by other companies also.

Mica Procurement and Processing

In normal times mica was purchased in the form of cut or uncut film 0.001 to 0.003 inch thick from concerns which imported the material from India. Because the supply of India mica to the United States became sharply reduced due to transportation difficulties, it was necessary for the War Production Board to issue Conservation Order M-101 in March 1942 to allocate the material properly and, furthermore, to develop domestic resources and to encourage the exploitation of mica deposits in Brazil and Canada.

Studies were pushed ahead to evaluate not only the mica from Brazil and Canada but also to examine samples from Guatemala, Peru, New Mexico, South Dakota, and Connecticut, as well as samples from the better known domestic sources in North Carolina, Georgia and New Hampshire. Good-quality mica capacitors were produced from a large number of the samples, but unfortunately the supply of many of the new sources could not be assured and the variability in the mica qualities was such that standard manufacturing routes could not be maintained.

A more thorough evaluation of the domestic micas was undertaken and completed through the joint efforts of the War Production Board, the National Research Council, Bell Telephone Labora-



Dial-feed mica punching machine, having mechanical fingers that hold the mica accurately in position and bring it close to the punch and die

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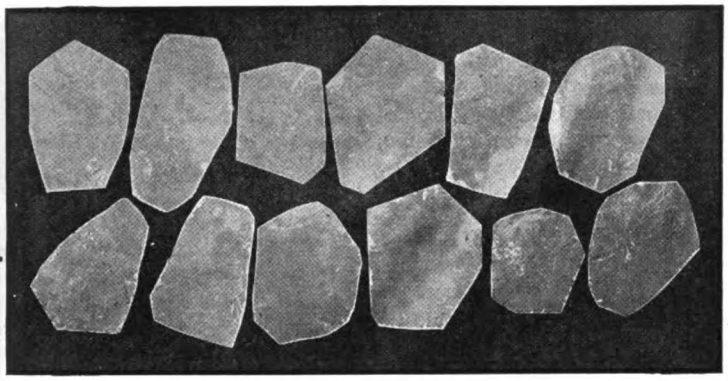
CAPACITORS



Quality B mica, showing maximum allowable air inclusions

tories and eight participating capacitor manufacturers. The results indicate the possible application of many grades of micas that were heretofore considered unsuitable for capacitor use.

Mica Conservation Program

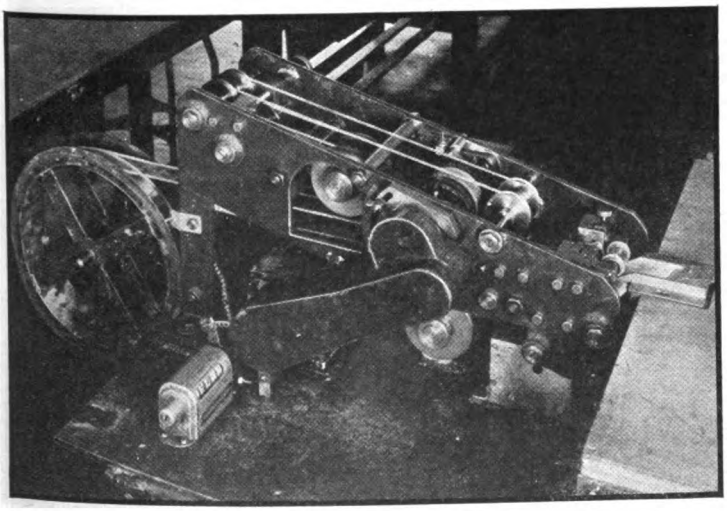
In addition to pursuing an active program for replacing mica capacitors with paper, ceramic, polystyrene and other capacitors, several changes were initiated in order to conserve strategic mica.

First, a new mica specification was written in agreement with the mica processors to define accurately the material required. The specification describes three empirical qualities, namely A, B and C, which are ample for normal manufacturing purposes. Quality B, which corresponds to the best second-quality film in shipments received from the joint British-American Mica Mission during 1944, has replaced better than 90 percent of the fair-stained India mica formerly used by the Western Electric Company.

Second, extra sorting for size was instituted so that an uncut film only slightly larger than the finished part would be used. Although this extra handling effort is costly, the resultant saving in mica makes it justifiable because the cost of the mica increases sharply with the larger sizes due to the limited supply. As a further conservation measure, the use of remnants after punching for making smaller parts was considerably increased even though it resulted in higher labor costs.

Third, a dial-feed mica punching machine was developed. The important feature of this machine is that the mica can be held by mechanical fingers very close to the punch and die, and the template in front of the operator permits accurate location of the part. Experience indicates that the yield of good parts per hour exceeds that obtained by punch press operation even with mica which has been previously sorted to be only slightly larger than the template. Incidentally, the extra cost of sorting is, to a large extent, offset by the increased productivity of these machines.

Fourth, the operator training program was revamped to meet conditions resulting from the higher rate of labor turnover being experienced and to assure the more painstaking handling of mica through all processes, with emphasis being placed on its strategic nature.



Mica masking machine, used to arrange laminations in a continuous strip ready for spraying with silver

Silver Coating

Over 80 percent of the mica used by the Western Electric Company is coated with a thin film of silver on each side. The purpose of the silver film is to obtain the excellent capacitance stability which results from the intimate contact between the conducting film and the mica. A further advantage is the ease with which precise capacitance adjustments can be made by scraping off small portions of the silver coating. The use of sil-

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ver-coated mica was introduced to improve stability and to facilitate the manufacture of potted telephone-type mica capacitors which generally are made to limits of ±0.25 percent.

In applying the silver coating, the mica is first suitably masked, then sprayed with a commercial silver solution and fired in a conveyor furnace at a temperature below 1100°F. The masking is accomplished on special machines which apply tape to mask the side margins of a mica lamination. The end margins are masked by overlapping the laminations as they are fed into the machine. The masked strips are racked, sprayed, and then fired in the furnace.

Stacking and Adjusting

The operation of stacking mica capacitors requires the alternate interleaving of mica and foil, and is a real challenge to the time and

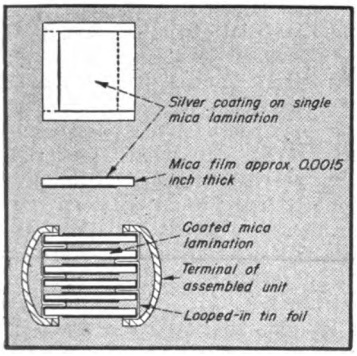

FIG. 1—Assembly of laminations

motion economist. The design of the workplace, with the supply of mica, foil, and terminals immediately adjacent to the recessed nest into which the parts are laid, is important. Needless to say, all types of capacitors cannot be advantageously assembled in a single type of workplace, and no two manufacturers appear to use identical methods. A complete description of the different methods is beyond the scope of this article; however, a brief resumé of the method used for assembling the majority of the silvered mica capacitors at the Western Electric Company may be of interest.

Silvered mica laminations are assembled with foil looped-in to make electrical contact between the silvered coatings and the terminals, as illustrated in Fig. 1. Lead foil from 0.0005 to 0.001 inch thick, with a tin content of less than 10 percent is used. The purpose of looping-in the foil is to permit a continuous electrical connection between the stack and a precise capacitance meter during assembly. This arrangement, together with the adjusting operation described later, assures that the capacitor will be within limits in spite of relatively wide variations in the thickness of the mica. Consequently, it is practicable to apply terminals and to test for dielectric strength at the assembly position. The need for assembling surplus capacitors to take care of fall-outs in subsequent tests is largely eliminated.

After stacking, the capacitor units are dried at atmospheric pressure for about 1½ hours at 300°F, a relatively short time which has proven to be practicable because all assembly operations are performed in an air-conditioned space where the relative humidity is maintained under 40 percent at 75°F. The dried units are adjusted within final capacitance limits by scraping off small portions of silver coating from the top lamination. Normally, the adjusting limits are about half of the final limits in order to compensate for variables in the potting or molding operation.

Final Assembly

The capacitor assembly may be completed in numerous ways, i.e., potted in metal containers, molded cases, or hermetically-sealed cans or molded directly in thermosetting or thermoplastic materials. The molding and potting techniques are well established and depend on the design of the capacitor and the volume of production.

The method used for molding capacitors may be of interest. Four to twenty cavity molds are mounted on inverted Hannifin pneumatic presses. The molds with few cavities are loaded by hand and those with eight or more cavities by means of loading boards. The knockout is pneumatically operated and controlled by a foot-pedal. The mold is first loaded with preforms, which are made from

Layout for assembling silvered mica capacitors with looped-in foil, with provisions for checking capacitance continuously during assembly

low-loss mineral-filled thermosetting material, then with the capacitor unit, and finally with a preform on top.

The loaded mold is pushed to the rear position and the pressure on the unit is applied slowly, 1 inch per minute or less, until a pressure of approximately two tons per square inch is reached. The small units are cured at 300° ± 10°F for approximately two minutes and the large units from three to four minutes, a time which undercures the molding material. The capacitors are then stamped with code and capacitance markings, and given a final stabilization bake for one hour at 250°F. The undercuring, followed by a final baking, not only saves valuable press time, but minimizes capacitance shifts.

Final inspection is performed on precision electrical testing equipment which is located in an air-conditioned room. Since most of the mica capacitors produced by this method are required to have a capacitance precision of better than ±1 percent, the testing equipment is very carefully designed, calibrated, and maintained.

Requirements and Problems

Prior to the war, mica capacitors were designed for operation under the temperature and humidity conditions encountered in indoor locations in the United States. These normally range from 60° to 120°F and with maximum humidity of 95 percent prevailing for short summer periods. The service condi-

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ions for military equipment involve much more difficult operating conditions, namely, temperatures ranging from −50° to +185°F and humidities up to 100 percent prevailing in many cases over most of the year. Yet the designers of airborne and ground communication and electronic equipment demand the same high degree of performance over this greater temperature range and under these more damaging humidity conditions.

New capacitor designs for ground signal equipment, which normally uses low frequencies and relatively large capacitance units, required potting in hermetically-sealed containers. New designs for radio equipment, which uses the smaller molded units, required the introduction of new processes for stabilization over the wide temperature range and new materials for sealing the terminals in order to protect units from humidity.

A typical manufacturing and design problem was the change required to assure conformance with a severe humidity requirement placed on molded capacitors which were used on special military equipment. It was necessary at the start to check 100 percent of the molded mica capacitors. Subsequently, experiments proved that Neoprene cement applied to the leads greatly improved the yield of capacitors and reduced the inspection costs. Further investigation showed that solutions of Vinylite VMCH and XYNC were even more effective in sealing the units against humidity and were easy to apply.

Manufacturing experience has shown that relatively poor stability and high values of temperature coefficient will result with the best quality of mica unless proper precautions are taken in the assembly, processing and molding of the units. Manufacturing methods were worked out to assure high stability with temperature and time for molded mica capacitors covering capacitances up to 20,000 $\mu\mu$f. Some of these are made to a capacitance tolerance of ± (0.5 percent + 1$\mu\mu$f), have a temperature coefficient of less than 15 parts per million per degree Fahrenheit over the temperature range of −50° to +185°F, and retrace to within 0.05 percent of the initial capacitance after repeated thermal cycling over this range. Such capacitors are being made because critical electronic equipment will not operate precisely without them.

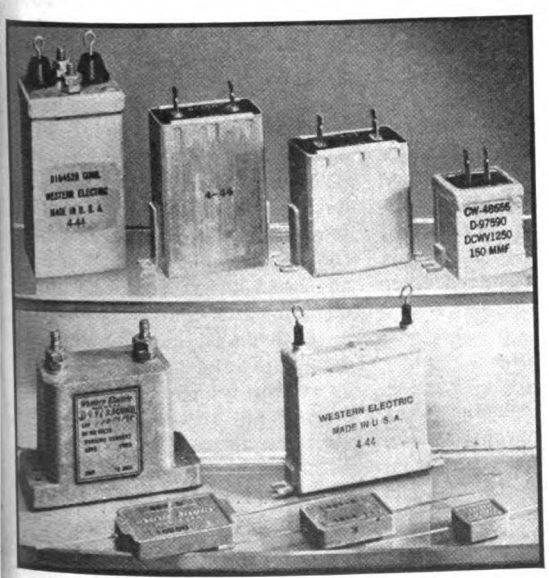
Use of Mica Substitutes

In view of some of the problems and processes discussed above, a brief statement concerning the use of paper and other types of capacitors as alternates may be in order. The development and application of small molded, mineral-oil filled capacitors has been accomplished to a considerable extent. Designs have been devised and are in production that are both mechanically and electrically interchangeable with the mica types.

As has been well publicized, many synthetic micas have been developed and have helped insofar as they could replace mica in capacitors for special applications. However, to date none of the available alternative dielectric materials compare favorably in all characteristics with mica—even with the lower grades of mica that remain practically untouched.

Continued effort to make certain that the lower grades of mica are used wherever the requirements permit, and that the available stocks are processed with the great care this precious material deserves, will go far toward assuring an adequate supply of mica capacitors.

The improvements in the processes and facilities for manufacturing mica capacitors reported above are to a large extent based upon the unified efforts of the engineering staffs of the Western Electric Company and Bell Telephone Laboratories, which the author gratefully acknowledges.



Representative examples of the nine types of molded and potted mica capacitors now being made by Western Electric

Adjusting finished silvered mica capacitors to exact capacitance value by scraping silver from the top lamination

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ARTIFICIAL

By SIDNEY WALD
Advanced Development Engineer
RCA Victor Division
Radio Corporation of America
Camden, N. J.

ARTIFICIAL ANTENNAS are necessary for testing variable-frequency radio equipment under conditions closely approximating those encountered in service. It is impractical to use an actual antenna in laboratory tests because radiated energy must be kept at a minimum, and it is usually inconvenient to precisely duplicate an antenna which is used in a special application such as on aircraft.

Although artificial antennas are used for both transmitters and receivers, the complexity of the antenna matching problem is not the same for both classes of equipment. This difference arises mainly because most receiver antenna circuits are untuned while transmitter output circuits, to deliver maximum power to the radiator, must be closely adjusted at each frequency. Because of the greater relative importance of the latter problem, this paper will concern itself with transmitting rather than receiving antennas.

Need for a greatly improved artificial antenna for transmitters became apparent during the author's experience in the design and testing of aircraft communication transmitters in the medium to high-frequency band. Types of dummy load in wide use for this purpose, while perfectly satisfactory for use at a single frequency, resulted in much loss of time and were excessively bulky when applied to equipment having a frequency range of one to ten megacycles. To speed up variable-frequency tests, which at times had to be performed under reduced atmospheric pressure to simulate high-altitude flight conditions, a fixed network was designed which matched the actual antenna both for resistance and reactance at all frequencies.

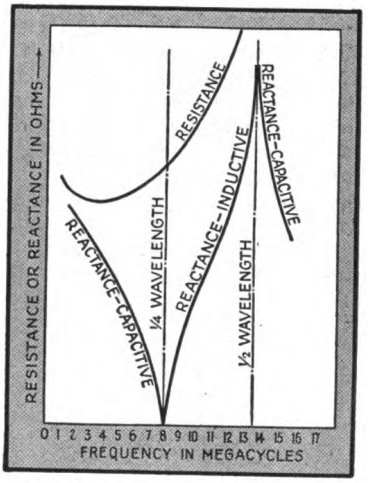

FIG. 1—Typical impedance variation of an antenna of fixed length when the frequency is varied, showing reactance variation as a tangent function of frequency

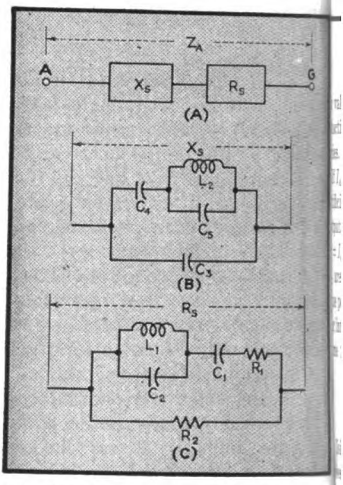

FIG. 2—(A) Antenna impedance can be represented by variable series reactance and resistance. (B) The reactance component and (C) the resistance component can be simulated by lumped constants

TABLE I—MINIMUM REQUIRED DATA FOR ARTIFICIAL ANTENNA DESIGN

(1) Reactance and resistance at the lower frequency limit.

(2) Quarter-wavelength frequency and resistance.

(3) Resistance at some critical frequency between upper frequency limit and quarter-wavelength frequency.

(4) Resistance at the upper frequency limit.

(5) Half-wavelength frequency. (If this frequency is not known, it can be assumed to be approximately 1.67 times the quarter-wavelength frequency. This constant is empirical and was selected as an average during a study of many fixed, single-wire antennas.)

Basis for Design

While theoretical considerations in this paper are general, this discussion is limited to a band from approximately one to twenty mc. The antenna for which an equivalent circuit is desired is the single-conductor type operating against a ground. The configuration of the wire may be horizontal, vertical, straight, or folded V. The quarter-wave resonant frequency of such a radiator usually lies between 5 and 10 mc. The characteristics of the antenna which must be known are given in Table I. A typical impedance characteristic is shown in Fig. 1.

To properly evaluate various requirements of a good dummy antenna, it is necessary to understand the way in which the impedance of an actual antenna varies with frequency. The equivalent circuit of an antenna is that of a series reactance X_s and series resistance R_s as shown in Fig. 2A. These two components of impedance change with frequency. The variations of X_s and R_s with frequency given in Fig. 1 apply to all types of antennas where size and geometry remain fixed, while the frequency is changed. To simulate such an antenna at a given frequency it is only necessary to connect the pro-

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ANTENNA

Design of a two-terminal, lumped-constant network that simulates, within a specified frequency band, the impedance variations of a single-wire antenna. The resulting artificial antenna can be used for tuning transmitters and for power measurements

per values of resistance and either inductive or capacitive reactance in series.

If I_A is the current flowing in the artificial antenna circuit, the power output of the transmitter would be $P = I_A^2 R_s$. If the values of X_s and R_s are correctly chosen, P will be true power output of the transmitter into the actual antenna at the same frequency.

Single Series Circuits

Using fixed *R-C* and *L-C* combinations to simulate the antenna is accurate and simple, but lacks flexibility where a continuous frequency band must be covered. The circuit consists of either a fixed capacitor or coil in series with a nonreactive resistor. The constants of the inductor or capacitor and resistor are calculated from the given antenna reactance, radiation resistance, and frequency.

The fixed resistance is made equal to the antenna resistance. The series capacitance is $C_s = 1/2\pi f X_A$ where X_A is negative. For positive values of X_A the antenna is inductive and $L_s = X_A/2\pi f$.

To provide an arrangement that is easier to work with when the frequency is frequently changed, the reactive and resistive components are made adjustable as, for example, a variable capacitor in series with a carbon compression resistor. When the antenna is inductive, a variable inductor is substituted for the capacitor. To further increase the versatility of the artificial antenna, both an inductor and a capacitor can be included in the series circuit, and a switch provided to short the unwanted element.

Although these adjustable circuits are theoretically sound, they seldom are satisfactory over a wide frequency range. In addition to their stray capacitance to ground, adjustable inductors have a high distributed capacitance. This may give rise to spurious resonances. Variable capacitors of high maximum capacitance must be extremely large to withstand the high r-f potentials.

Not only are there practical electrical difficulties, but there are the operational disadvantages which require the manipulation of two controls for each change in output frequency. An error in setting of either the reactor or resistor results in unreliable measurements and a loss of time in rechecking results.

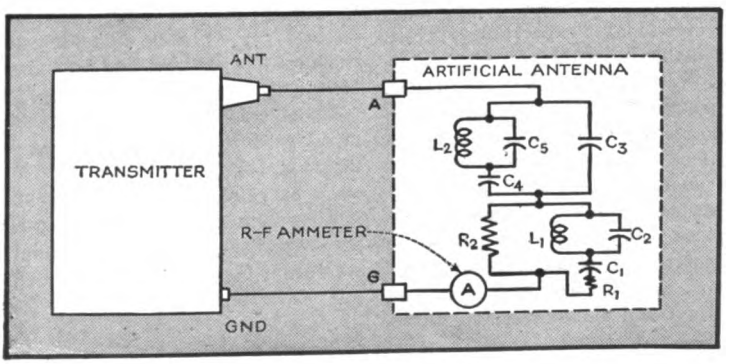
Composite Series Circuits

In contrast to the foregoing circuits that utilize variable components, the proposed artificial antenna is composed of fixed elements. When these elements are properly chosen, the reactance and resistance seen at the terminals of the network (Fig. 2A) will match those of the actual antenna at every frequency within the assumed limits.

It is the plan of this paper to treat each portion separately and finally to show how they are connected in series to form the desired circuit. The portion marked X_s will automatically duplicate the series reactance of the given antenna, while R_s will produce the resistance variation with frequency. Although in practice it is not possible to isolate resistance and reactance completely, it is assumed that the equivalent series resistance of the reactance section is low enough to be negligible and the equivalent series reactance of the resistance section can be disregarded in comparison with that contributed by the reactive circuit.

Network Equations

A combination of reactances which can have an equivalent series reactance variation with frequency similar to that shown in Fig. 1 is represented in Fig. 2B. The cor-



An r-f ammeter can be included in the artificial antenna for power measurements. Stray capacitances must be held to a minimum

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TABLE II—REACTANCE NETWORK DESIGN EQUATIONS

Units are in farads, henrys, cycles, and ohms.

1) Assume a value for C_s

(2) $$C_s = \frac{(\omega_2^2 - \omega_1^2)(-X_1\,\omega_1\,C_2 - 1) - X_1 C_2\,\omega_1\,(\omega_3^2 - \omega_2^2)}{X_1\,(\omega_1\,\omega_3^2 - \omega_1^2)}$$

where $C_s = C_4C_5/(C_4 + C_5)$
ω_1 — angular velocity at lower limit
ω_2 — quarter-wavelength angular velocity
ω_3 — half-wavelength angular velocity
X_1 — antenna reactance at ω_1 (proper sign must be used for X_1 when substituting into equation)

(3) $$C_4 = C_s\,(\omega_3/\omega_2)^2 - C_s\,(\omega_2\,L\,\omega_3)^2/\omega_2^2$$

(4) $$C_5 = C_sC_4/(C_4 - C_s)$$

5) $$L_2 = 1/\omega_2^2\,(C_4 + C_5)$$

Note: (A) If ω_2 is unspecified it can be assumed to be 1.67 ω_3, as stated in Table 1 (5); (B) The Q of L_2 should be as high as possible, at least 300; (C) Distributed capacitance of L_2 should be subtracted from the calculated value of C_5 to determine the physical value for C_5.

(6) To check accuracy of computed components, plot X_s vs angular velocity from the following equation, and compare this curve with the given antenna reactance curve

$$X_s = \frac{\omega^2 L_2\,(C_4 + C_5) - 1}{\omega C_5\,[1 - \omega^2 L_2\,(C_4 + C_5)[-\omega C_4\,(\omega^2 L_2 C_5 - 1)}$$

responding frequency characteristic is shown in Fig. 3A.

The problem is to select values of C_s, C_4, C_5, and L_2 to yield a reactance variation which duplicates that of any given antenna. While C_s is theoretically unnecessary to obtain the simulated curve, in practice it was found that the stray capacitance from the antenna terminal to ground introduced a large error in reactance at the low-frequency end of the band. Using a controlled value of C_s eliminates the effect of this unavoidable capacitance. Thus some value is selected for C_s greater than the supposed stray capacitance to ground and if the final capacitance to ground is smaller than the assumed value, a trimmer capacitor can be inserted to make up the difference. A practical value for C_s is about 10 $\mu\mu$f.

Design equations for this reactance network are derived in Appendix I and summarized in Table II.

In a similar manner, the network of Fig. 2C provides the required resistance variation. Design equations for this network are derived in Appendix II and summarized in Table III. The quantities referred to in this table are made clear by Table I and Fig. 3B.

Example of Network Design

Pertinent data concerning the reactive characteristics of an antenna is: Lower limit frequency = 2 mc, reactance at lower limit frequency = $-j$ 930, quarter-wave frequency = 9.3 mc, and half-wave frequency = 15.5 mc.

From this data, values for substitution into Table II are: $\omega_1 = 2\pi\ (2 \times 10^6)$, $\omega_3 = 2\pi\ (9.3 \times 10^6)$, $\omega_3 = 2\pi\ (15.5 \times 10^6)$, $X_1 = -930$, and let $C_s = 10 \times 10^{-12}$. Solving for the reactive network components, we obtain $C_s = 20.3$ $\mu\mu$f, $C_4 = 69.9$ $\mu\mu$f, $C_5 = 28.7$ $\mu\mu$f, and $L_2 = 2.96$ μh.

If these values are substituted into the equation for X_s and reactance plotted against frequency, the upper curve of Fig. 4 is obtained. Checking the value of X_s against actual antenna reactance at any frequency shows that the error at any point is well within the limits of engineering accuracy. In this

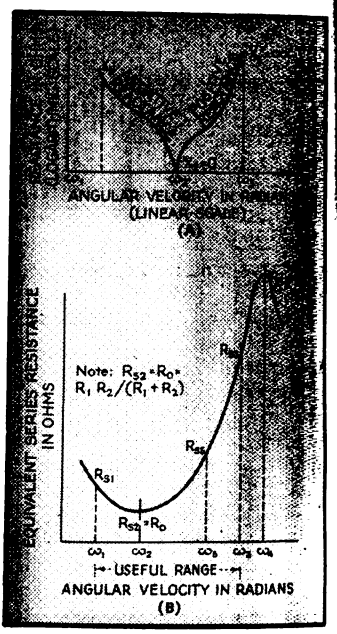

FIG. 3—Critical frequencies and their associated reactances (A) and resistances (B) of the antenna to be simulated are used to obtain values for the artificial antenna elements

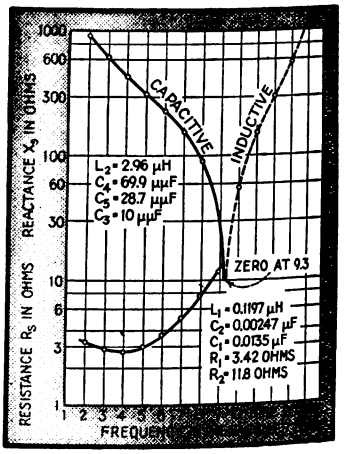

FIG. 4—An artificial antenna built from the design equations was tested and had these reactive and resistive characteristics; compare with Fig. 1

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particular example, the reactance error at any frequency is less than two percent.

To complete the sample calculations, the significant resistance values of the given antenna with reference to Fig. 3B are: $R_{s1} = 3.2$ ohms, $f_1 = 2$ mc or $\omega_1 = 2\pi (2 \times 10^6)$, $R_o = 2.7$ ohms, $f_2 = 4$ mc or $\omega_2 = 2\pi (4 \times 10^6)$, $R_{s5} = 6$ ohms, $f_5 = 7.5$ mc or $\omega_5 = 2\pi (7.5 \times 10^6)$, $R_{s3} = 11.5$ ohms, and $f_3 = 9$ mc or $\omega_3 = 2\pi (9 \times 10^6)$.

Substitution of the preceding constants into the equations of Table III gives $R_2 = 11.8$ ohms, $f_4 = 9.275$ mc, $C_1 = 0.0135$ μf, $L_1 = 0.1197$ μh, $C_2 = .00247$ μf, and $R_1 = 3.42$ ohms.

If these values are substituted in the equation for R_s and the resultant values plotted against frequency, the lower curve of Fig. 4 is obtained.

The actual artificial antenna is the series combination of the resistive and reactive networks.

Reactance Error due to Resistance Network

Lumping the reactive elements of the resistance network of Fig. 2C into a single reactance X_1, we find that the reactance of the resistance network is

$$X_s = X_1 R_2^2 / |(R_1 + R_2)^2 + X_1^2| \qquad (1)$$

To find the greatest value that X_s can ever reach, differentiate Eq. (1) with respect to X_1

$$\frac{d(X_s)}{dX_1} = \frac{[(R_1 + R_2)^2 + X_1^2] R_2^2 - (X_1 R_2^2) 2 X_1}{[(R_1 + R_2)^2 + X_1^2]^2}$$

Setting the numerator equal to zero, and solving for X_1

$$X_1 = R_1 + R_2 \qquad (2)$$

Substituting Eq. (2) into Eq. (1)

$$X_{s\max} = R_2^2 / 2 (R_1 + R_2) \qquad (3)$$

In a typical case where $R_2 = 11.8$ ohms and $R_1 = 3.42$ ohms, the maximum value of X_s is 4.56 ohms inductive. Substituting Eq. (2) in Eq. (10) from Appendix II gives

$$R_s = \frac{R_2 (R_2 + 2R_1)}{2 (R_1 + R_2)} \qquad (4)$$

Using the same numerical values for R_1 and R_2, $R_s = 7.2$ ohms.

Referring to the antenna resistance curve of Fig. 4B, we see that $R_s = 7.2$ ohms at a frequency of 7.9 mc. At this frequency the antenna reactance is $-j100$ ohms. Thus, in the given example, the maximum error introduced by the reactance of the resistance variation circuit occurs at 7.9 mc and has a value of $X_{s\max}/X_A = 4.56/100 = 4.56$ percent.

Antenna Operation

The simulative network discussed in this paper is, strictly speaking, only an approximation of the antenna which it is intended to replace. At any frequency the simulated reactance and resistance will differ from the actual values by a finite amount. The magnitude of these discrepancies will vary depending on the antenna, but in general it will be found that the reactance curve can be made to match within two percent, while the resistance may deviate as much as ten percent from the true value.

Effect of mismatch on the tuning of the transmitter output circuits may for all practical purposes be neglected. However, the setting of the coupling control, being sensitive to the resistive component of the antenna impedance, will differ slightly at some points from its position when working into an actual antenna.

The network may be used for measuring power output if a radio-frequency ammeter is connected in series with the circuit. The power output is $P = I_A^2 R_s$ where P is power output in watts, I_A is amperes rms, and R_s is equivalent series resistance of entire network. The value of R_s at each frequency should be determined by measurement on either a Q meter or a suitable r-f bridge, between terminals

TABLE III—RESISTANCE NETWORK DESIGN EQUATIONS

Units in farads, henrys, cycles, and ohms.

(1) Solve for R_2 from the following equation, using given values from the antenna to be duplicated

$$\pm N [A (R_2 - R_{s5})]^{1/2} \mp M [F (R_2 - R_{s1})]^{1/2} = (N - M) [R_2 - R_{s3}]^{1/2}$$

where $A = \dfrac{(R_{s3} - R_o)/(R_{s5} - R_o)}{\left[\dfrac{\omega_5}{\omega_3}\left(\dfrac{\omega_2^2 - \omega_3^2}{\omega_2^2 - \omega_5^2}\right)\right]^2}$

$$F = \frac{(R_{s3} - R_o)/(R_{s1} - R_o)}{\left[\dfrac{\omega_1}{\omega_3}\left(\dfrac{\omega_2^2 - \omega_3^2}{\omega_2^2 - \omega_1^2}\right)\right]^2}$$

$$M = \omega_5^2 - \omega_3^2$$

$$N = \omega_1^2 - \omega_3^2$$

(2) Having found R_2, solve for ω_4 from

$$\omega_4 = [(\pm \omega_5^2 B - \omega_3^2)/(B - 1)]^{1/2}$$

where $B = \left[\dfrac{R_2 - R_{s3}}{A (R_2 - R_{s5})}\right]^{1/2}$

(3) $C_1 = \left(\dfrac{\omega_2^2 - \omega_5^2}{\omega_5^2 - \omega_4^2}\right)\left(\dfrac{\omega_4^2}{\omega_2^2 \omega_5^2 R}\right)$

where $R = \dfrac{R_2^2}{R_2 - R_o}\left[\dfrac{R_{s5} - R_o}{R_2 - R_{s5}}\right]^{1/2}$

(4) $L_1 = (\omega_4^2 - \omega_2^2)/\omega_4^2 \omega_2^2 C_1$

(5) $C_2 = 1/\omega_4^2 L_1$

(6) $R_1 = R_o R_2/(R_2 - R_o)$

(7) To check accuracy of the calculated components, plot R_s vs angular velocity from the following equation and compare this curve with the given antenna resistance curve

$$R_s = \frac{(R_1 R_2)(R_1 + R_2) + R_2 X_s^2}{(R_1 + R_2)^2 + X_s^2}$$

where $X_s = (-1/2\pi f C_1) + \dfrac{2\pi f L_1}{1 + (4\pi^2 f^2 L_1 C_2)}$

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A and G.

To get reliable indications of antenna current, the stray capacitance of the input terminal and of C_1' to ground must be reduced to as low a value as possible. Careful arrangement of the elements of the network, together with a short input lead, will increase the accuracy of power output measurements.

There are several precautions to be taken in connection with the design, construction, and use of the artificial antenna described here. The various components of the network must be carefully chosen to give satisfactory service. This caution is particularly applicable to capacitor C_1 which may be subjected to extremely high r-f potential, even with low-power transmitters. For example, at two megacycles, a transmitter which produces 20 watts in an antenna resistance of three ohms causes a current of 2.57 amperes rms to flow. Using the value of C_1 in our typical case, 69.9 $\mu\mu$f, the current in C_1 would be 2.25 amperes. The peak voltage across C_1 with 100-percent modulation is $2 \times 1.4 \times 1140 \times 2.25 = 7{,}160$ volts.

In conclusion, while the antenna network presented here falls considerably short of perfection, it does have a substantial field of usefulness from an engineering point of view. The effort consumed by its design and construction is small indeed when one considers the amount of time which can be saved in the development and testing of multi-frequency transmitters.

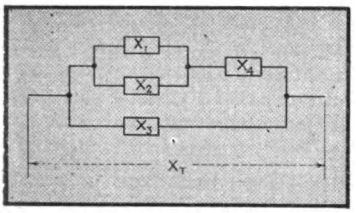

FIG. 5—Assumed circuit from which reactive network is developed

Appendix I Simulation of Reactance Curve

Neglect the resistance in the circuit. The reactive portion of the simulated antenna can be represented by Fig. 5. The total circuit reactance is

$$X_T = \frac{X_1X_2X_3 + X_3X_4(X_1 + X_2)}{X_1X_2 + X_4(X_1 + X_2) + X_3(X_1 + X_2)} \quad (5)$$

let $X_1 = +\omega L_2$
$X_2 = -1/\omega C_5$
$X_3 = -1/\omega C_5$
$X_4 = -1/\omega C_4$

Substituting these values into Eq. (5) gives

$$X_T = \frac{\omega^2 L_2 (C_4 + C_5) - 1}{\omega C_5 [1 - \omega^2 L_2 (C_4 + C_5)] - \omega C_4 (\omega^2 L_2 C_5 - 1)} \quad (6)$$

when $\omega = \omega_2$, $X_T = 0$

$$\omega_2^2 L_2 (C_4 + C_5) - 1 = 0 \quad (7)$$

when $\omega = \omega_3$, $X_T =$ infinity

$$C_5 [1 - \omega_3^2 L_2 (C_4 + C_5)] - C_4 (\omega_3^2 L_2 C_5 - 1) = 0 \quad (8)$$

when $\omega = \omega_1$, $X_T = X_1$

$$X_1 = \frac{\omega_1^2 L_2 (C_4 + C_5) - 1}{\omega_1 C_5 [1 - \omega_1^2 L_2 (C_4 + C_5)] - \omega_1 C_4 (\omega_1^2 L_2 C_5 - 1)} \quad (9)$$

Equations (7), (8), and (9) are now solved simultaneously for unknowns C_4, C_5, and L_2, giving the equations of Table II.

Appendix II Simulation of Resistance Curve

In the network of Fig. 6A the equivalent series resistance, R_s, as shown at Fig. 6B is a function of the branch reactance X_1 which in turn is some function of frequency; thus

$$R_s = \frac{(R_1 R_2)(R_1 + R_2) + R_2 X_1^2}{(R_1 + R_2)^2 + X_1^2} \quad (10)$$

This circuit is satisfactory for our purpose because the equivalent series reactance X_s can at all times be made small compared to either the total series resistance or the total series reactance. This total series reactance includes the reactance developed in Appendix I. We are primarily concerned with the duplication of a resistance variation. The magnitude and importance of X_s is considered elsewhere.

The minimum value of R_s in Eq. (10) occurs when $X_1 = 0$ and $R_s = R_0 = R_1R_2/(R_1 + R_2)$. If Eq. (10) is solved for X_1 we obtain

$$X_1 = \pm \left[\frac{(R_1 R_2)(R_1 + R_2) - R_s (R_1 + R_2)^2}{R_s - R_2}\right]^{1/2} \quad (11)$$

From the condition for a minimum value of R_s, $R_1 = R_0R_2/(R_2 - R_0)$, which, substituted into Eq. (11), gives

$$X_1 = \left(\frac{R_2^2}{R_2 - R_0}\right)\left[\frac{R_0 - R_s}{R_s - R_2}\right]^{1/2} \quad (12)$$

Now if in Fig. 6A, X_1 assumes the configuration of Fig. 6C.

$$X_1 = \frac{1 - \omega^2 L_1 (C_1 + C_2)}{\omega C_1 (\omega^2 L_1 C_2 - 1)}$$

Substituting this value of X_1 into Eq. (12) yields

$$\frac{1 - \omega^2 L_1 (C_1 + C_2)}{\omega C_1 (\omega^2 L_1 C_2 - 1)} = \frac{R_2^2}{R_1 - R_0}\left[\frac{R_0 - R_s}{R_s - R_2}\right]^{1/2} \quad (13)$$

If ω_4 is the angular frequency at which the L_1C_2 loop is in parallel resonance, that is: $L_1C_2 = 1/\omega_4^2$, and similarily, if ω_2 is the angular frequency at which the circuit of Fig. 6C is in series resonance so that $L_1 (C_1 + C_2) = 1/\omega_2^2$, Eq. (13) can be written in terms of resonant and antiresonant angular velocities.

There are three unknowns in this resultant equation, namely, R_s, ω_4 and C_1. If three conditions are known, a corresponding number of simultaneous equations can be set up. The most convenient boundary conditions are the two limit frequencies and one intermediate frequency, and the corresponding antenna resistances. Using these values to solve this equation gives the design equations of Table III.

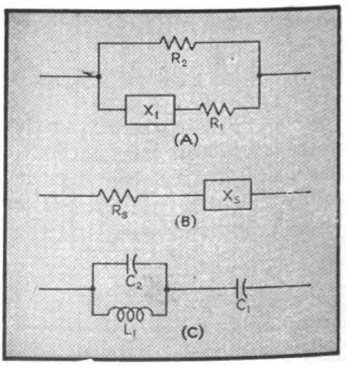

FIG. 6—Circuit from which resistive network is developed: (A) the assumed circuit, (B) the equivalent series circuit, and (C) the final design

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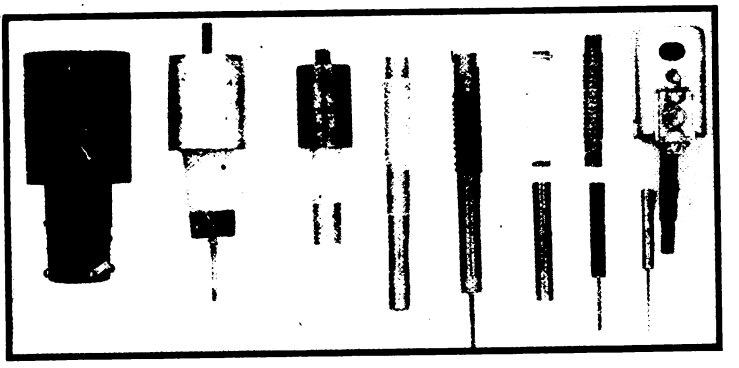
Permeability Tuning

Survey of applications for movable pulverized iron cores in postwar a-m, f-m, and television receivers, and analysis of factors to be considered in designing permeability tuners

By W. J. POLYDOROFF
Consulting Engineer
Chicago, Illinois



Evolution of permeability tuners. Left to right: Early pot tuner; British tuner with tapered coil; small, high-Q pot-type tuner; five versions of the modern tuners described in this article

With manpower, raw materials, and plant capacity now available for producing home and auto radio receivers, the following facts about permeability tuning constitute a timely aid in the design of postwar sets.

Judging from pre-war acceptance of systems of tuning in which inductance was varied instead of capacitance in tuned circuits, permeability tuning will be found in the majority of the auto sets and in a good share of home radios. The advantages are economy, compactness, light weight, stability, and absence of microphonics. In addition, in a series-resonant antenna circuit the use of permeability tuning compensates the customary lack of selectivity at the high-frequency end of the tuning range because it is possible to secure a substantially constant Q. In r-f amplifiers it is advantageous to employ circuits in which the ratio of L to R is a constant so that the amplification is maintained constant with uniform selectivity. In oscillator circuits, stability is gained by use of high Q and again permeability tuning has something to offer.

Superheterodyne Applications

Superheterodynes have been built with one or two stages of preselection. A two-gang tuner (preselector and oscillator) offers an attractive mechanical design since it is possible to arrange the two cores with continuous mechanical coupling so that both cores move and maintain tracking. At the same time the indicator may be actuated by mechanical coupling to the cores. When the police band is included, the preselector permeability tuner should provide an inductance variation of about 10 to 1 while the oscillator variation is of the order of 5 to 1. Tracking is accomplished by using two similar cores, having larger-diameter tubing for the oscillator, or by two similar forms and a smaller-diameter core for the oscillator. In addition, the oscillator coil may be wound with a progressive pitch which further improves the tracking.

If the public were deprived of the questionable entertainment of listening to police reports, then the inductance ranges for preselector and oscillator become 7.8 to 1 and 3.9 to 1 respectively, corresponding to the requirements for auto receivers.

While a few auto sets have been made with two-gang tuners, the low pickup of the auto antenna necessitates an additional r-f stage so that image-frequency problems and cross-modulation interference practically disappear. It must be borne in mind, however, that trf circuits require interstage shielding and shielding of a permeability-tuned inductor with open core reduces the inductance variation. Hence, it is necessary to start with a variation of inductance higher than 10 to 1 to arrive at the necessary 7.8 to 1 inside the shield.

In the construction of permeability tuners thin-walled tubing is used for coils, the practical wall thickness being approximately fifteen thousandths of an inch. The core usually fits inside the tube, with clearance of not over 0.002 inch, in order to realize the desired inductance variation. In the simplest case a single layer of enameled wire is wound over the tubing to an inductance of 80 to 100 microhenrys. Such a winding usually has a Q of 30 to 50 at 1,500 kc. With 6/42 wire and a ¼-inch diameter core it is possible to approach maximum Q of 100. When higher Q is desired the progressive universal winding is employed, using something like 10/42 or 20/44 Litz.

Analysis of Typical Tuners

Table I gives the characteristics of four sizes of permeability tuners which have either been in use before the war or appeared later. Types 1 and 2 were used before the war. Type 2 should be preferred in every case as it gives better performance, longer spread of frequencies on account of larger stroke, and better mechanical strength of the core itself. It also permits use of thicker-wall tubing. The differ-

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ence in the cost of the two cores is negligible as compared with other components. It is only in the case of the oscillator coil that type 1 can be used without material difference in performance.

Type 3 represents a core that was used in a commercial loop receiver in which a preselector circuit including a low-impedance loop was tuned by this core. It is believed that with improved techniques of pressing, this core may be reduced in length to 1½ inches and still maintain the same coverage. Fairly high Q is obtainable with this tuner when 20-strand Litz is employed.

In a large console it is possible to provide adequate spacing for a highly efficient tunable loop, but in a small receiver the loop is usually jammed against the chassis, with loss-producing metal in the field of the loop. In small sets the efficiency of a tunable loop may therefore be reduced by 6 db because of chassis losses.

A loop stage tuned by an iron-core inductor is shown in Fig. 1A. The loop is at the grounded end of the circuit, in series with a variable inductance. In addition to its simplicity this circuit possesses a low initial capacitance of the order of 2 to 3 $\mu\mu$f. The value of the inductance of a loop in series with a tuning inductance is determined from a simple formula

$$L_s = \frac{L_o\,[\mu_{eff} - (f_{max}^2/f_{min}^2)]}{(f_{max}^2/f_{min}^2) - 1}$$

where f_{max} and f_{min} are the desired limits of frequency, L_s is the inductance of the loop aerial, L_o is the minimum inductance of the tuner, and μ_{eff} is the total inductance variation of the tuner. The μ_{eff} of a usual iron-core tuner is 10, so that $L_s = 0.32L_o$ or roughly one-third of the minimum inductance for the broadcast range.

With $L_o = 300$ the value of L_s is 100 and the value of total capacitance becomes 24 $\mu\mu$f, which can be realized with a 10 to 20-$\mu\mu$f adjustable trimmer. In this case a loop in series with the inductor covers the entire broadcast range, with a loss of 3 db as compared with capacitor tuning.

Since a loop and its tuning inductor are interdependent, in the design of loop receivers the tuners and loops must be considered together for their frequency coverage and for oscillator tracking.

It is now possible to increase μ_{eff} to 16 and even 18, by the employment of closed-type binocular structure. Then a loop of 200 μh can be employed with $L_o = 200$ μh so that larger frequency coverage and full sensitivity are realized.

TABLE I. CHARACTERISTICS OF PERMEABILITY TUNERS

Type	Core			Coil				Winding	Q of Coil & Core	Application
	Diam.	Length	L/D	Diam.	Length	L/D	μ_{eff}			
1	0.198	1.375	7	0.225	1.2	5.4	10	Single layer enameled	30–70	Preselector coils for broadcast range
2	0.256	1.5	6	0.275	1.25	4.5	10	Single layer Litz	50–90	
								Prog. universal Litz 6/42	75–100	
3	0.312	1.875	6	0.35	1.625	4.5	11	Prog. univ.	100–125	
4	0.375	1.5	4	0.415	1.250	3.04	4	Single layer enameled	125–175	Short-wave 6–18 mc
				0.430	1.375	3.2	8.5	Prog. univ. Litz 20/44	125–150	Broadcast band high-Q coil

Short-Wave Applications

The large size of tuning core, ⅜-inch diameter by 1½ inches long, may employ high-grade iron powder suitable for short-wave reception. With finer subdivision of iron the effective permeability is reduced and it is impractical to attempt to cover the short-wave range from 6 to 18 mc with a single tuner. Several pre-war models used spread-band tuning in which cores covered partial frequency bands including the majority of international broadcast stations.

With the public demanding continuous tuning, a new core has been designed to cover the short-wave band in two steps: 6 to 11 mc, and 10 to 18 mc. Such distribution of short-wave stations somewhat approaches a band-spread dial yet offers continuous tuning throughout the whole range of frequencies. In practice this can be accomplished by one tuning unit with a choice of two values of fixed capacitors.

Figure 1B shows such an antenna circuit, with approximate values of inductance and capacitance. The coil is wound in the usual manner and can be made with No. 24 or 26 wire on a thin-walled tube. If, however, the frequency coverage is to be increased, say by 5 percent, two coil windings can be laid on the same tube side by side, with the windings wound closer together and preferably in reverse directions as shown in Fig. 1C. To obtain maximum effective permeability at higher frequencies the turns must be laid close together. By paralleling two or more sections of higher inductance we may get the total value of the inductor down to a desired value. The arrangement shown in Fig. 1C possesses higher Q since the adjacent turns are at the same potential, and therefore electrostatic losses are reduced. In certain vhf applications up to four sections wound in this manner were successfully employed, with the result that the effective frequency coverage was noticeably increased.

Figure 2 shows the manner in which Q varies with frequency for several of the permeability tuners covered in Table I. In general, Q decreases as frequency goes up.

Core-Molding Techniques

With existing core materials it is possible to employ permeability tuning at much higher frequencies, such as those for f-m and television. Smaller grain size should be employed to keep eddy current losses down, which in turn decreases the practical density of the core material and increases the number of gaps in the magnetic circuit. Both tend to reduce the permeability and consequently the permeability drops to a value of about 4 in the region of 100 mc, as contrasted to 30 for broadcast-band applications. Using the same geometrical dimensions of core and coil we may expect an inductance variation in broadcast receivers of the

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order of 10 to 1, in short-wave receivers of the order of 4 to 1, and less than 2 to 1 in the vhf bands.

In the production of long cores special techniques of pressing and molding have been developed. With pressure applied to the ends of the core a considerable friction develops in the mold, so that very high pressures are used to produce cores of desired density. Since the original powder mixture contains little plastic ingredients, the pressure is not readily transmitted toward the center of the core, resulting in decreased density and permeability in the middle region of the core. Worst of all, this degree and location of soft spot is never the same in two identically prepared cores. The result is that when two similar cores are moved into the coil, the gradient of inductance variation changes from one core to another, making it difficult to track two circuits together.

Several core makers have resorted to a double selection method in which the cores are matched fully in the coil, and also matched at the middle position. Thus it is possible to obtain uniform tracking in a selected family of cores, but the problem of replacements and interchangeability is complicated as the manufacturer is forced to maintain a stock of different families with several sub-families in each for replacement.

When excessive pressure is applied to both ends during molding, it becomes quite a problem to extract the core after it is pressed. One manufacturer employs split molds as a successful but slow method of extracting the cores.

Not long ago a core manufacturer introduced long cores which were strong and uniform throughout their length, both of these qualities being obtained by side pressing. This type of pressing uses a longitudinal mold cavity and both top and bottom plungers are rounded. The core compresses very easily since the depth of compression amounts to the diameter of the core. It is difficult to produce perfectly round cores by this method, but after the cores are completed they can be ground in centerless grinders, to a cylindrical shape.

Initial and Effective Permeability

For any given powder the initial permeability is a function of the density to which the mixture has been pressed. The initial permeability can only be realized in a toroidal coil and approached in a closed pot type. In open-type cylinder cores, the effective permeability is only a fraction of the full permeability and depends on the ratio of length to diameter and on the permeability of the material. The longer the cylinder is, the higher will be the effective permeability for variable inductors. The higher the permeability of the material, the higher is the effective permeability up to a certain value.

For further increase in the effective permeability two cores and coils may be employed in a binocular pair, or an elongated sleeve of the same material may be added on the outside of the coil.

Orientation of Core Particles

Additional increase in permeability may be obtained by using flat or flattened particles laid and compressed with their flat faces parallel. The pressure in this case is applied transversely to the flat faces, so that cylindrical cores have to be pressed lengthwise. By careful selection of flat particles having high permeability and careful alignment in the mold, it has been possible to produce permeability tuners of relatively short stroke, such as 1½-inch length for a ⅜-inch diameter core, with correspondingly shortened coil. If proper Litz and universal windings are used, high-Q permeability tuners may be made for the broadcast and police frequency range. A directional permeability, similar to laminated cores, is observed and obviously should be applied in the direction of the magnetic axis of the coil.

Other Considerations

Permeability tuning has been successfully applied to low-power transmitter circuits, using cores up to 2 inches in diameter and weights up to 2 pounds.

Higher-power applications, above 50 watts, have not yet been successfully solved, mainly because of the heat unavoidably generated in the core. This difficulty is further aggravated by the fact that the usual core materials are poor heat conductors and the organic materials employed for binding the core disintegrate under heat.

In cores for high-power applications it is essential to eliminate organic materials or entirely eliminate the binder and rely on sintering after compression to produce a quasi-laminated structure.

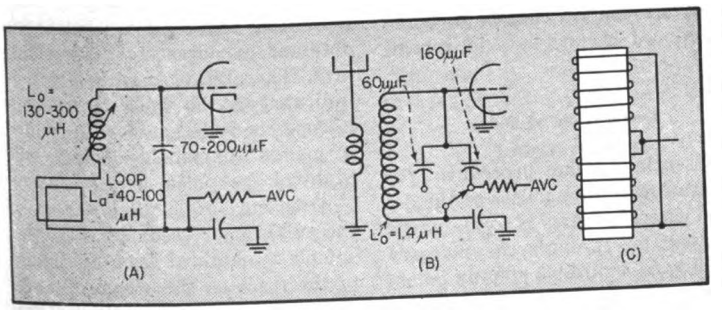

FIG. 1—Loop stage tuned by iron-core inductor (A), use of two fixed capacitors to provide coverage of a short-wave band in two steps with a pulverized iron core (B), and method of winding coil to obtain higher Q along with increased frequency coverage (C)

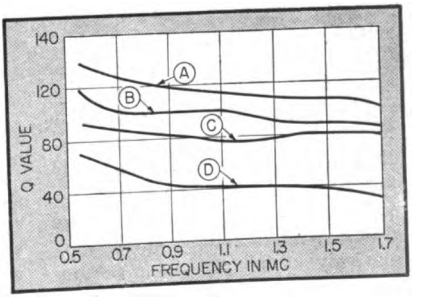

FIG. 2—Variation of Q with frequency for (A) 0.375-inch diam. core 10/44 Litz, (B) 0.256-in. core 6/42 Litz, (C) 0.198-in. core 6/44 Litz, and 0.198-in. core single layer enameled

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RESISTANCE

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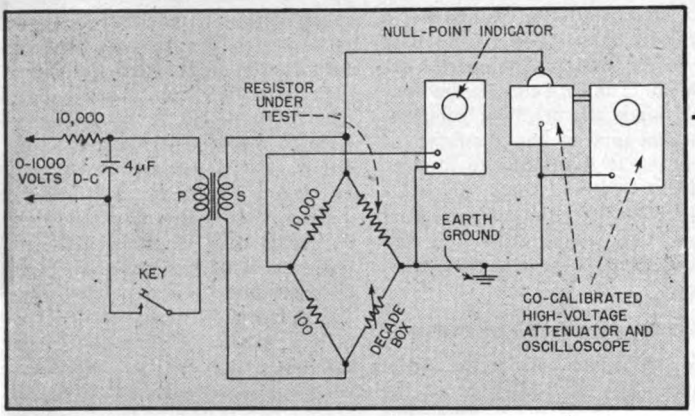

FIG. 1—Circuit for measuring the resistance of a suppressor subjected to high impulse voltage. One oscilloscope is employed as an indicator of the balance point of the bridge and the other for measurement of the peak voltage applied to the sample

COMPOSITION-TYPE resistors are ordinarily possessed of a voltage coefficient characterized by decreasing resistance as the voltage applied to the element increases. The rate of resistance drop with increasing voltage is dependent upon physical characteristics of the resistor such as, for example, the ingredients comprising the mix and the physical size in relation to the resistance value.

Problem of High Voltage

The suppression effectiveness of a resistor element applied to a high-tension ignition circuit is a function not necessarily of the resistance at low voltages, such as would normally be used in an ohmmeter circuit, but of the resistance at the instant of spark-plug discharge when the full high voltage of the system is impressed momentarily across the suppressor. The general range of ignition voltages is considered to be approximately from 5,000 volts to 12,000 volts, with the majority of motor vehicles normally operating near the lower limit

The measurement at low voltage of any given resistor sample is a relatively simple matter. A number of adequate methods are available and generally applicable for the condition under which the applied voltage does not greatly exceed the rated voltage of the sample, or under which the measurement can be made quickly enough so that appreciable heating of the sample does not occur. However, it is evident that commonly employed methods cannot be used where measurements are to be made with applied voltages of 5,000 to 12,000 volts and where the resistor element is a composition carbon suppressor rated at 10,000 ohms and ½ watt.

High voltages may be applied to the resistor element in question only momentarily if a serious heating effect is to be avoided. Thus a pulse of the desired peak value must be generated. As well as being of extremely short duration, it is desirable that the pulse be relatively free of higher harmonics and consequently approximately sinusoidal in wave form, yet capable of being reproduced accurately and repeatedly.

Generation of Pulse

Essentially, the procedure for generating voltage pulses of the desired characteristics is to discharge a capacitor through the primary winding of a suitable step-up transformer. The resulting voltage wave appearing across the secondary winding is actually a rapidly damped wave train of relatively short duration. The initial half-cycle will, with the use of proper circuit elements, reach a peak value of several thousand volts and be eminently satisfactory for the purpose of high-voltage resistance measurements.

One specific circuit is shown in Fig. 1. In this, the pulse is generated by closing the key, thereby discharging a 4-μf capacitor through the primary of a 3-kva, 60-cycle power transformer. A pulse of approximately 12,000 volts peak is developed across the loaded transformer secondary when the capacitor is charged to the full 1,000 volts just prior to discharge. The transformer windings consist of a 110-volt primary and a 3000-volt secondary.

The d-c power supply may be any source that is variable over the range from zero to approximately 1,000 volts and capable of withstanding a current drain sufficient to charge a 4-μf capacitor to 1,000 volts through a 10,000-ohm resistor once every second.

Resistance Measuring Circuit

The measurement is accomplished by use of the Wheatstone bridge circuit, one arm of which is the resistor sample under test. The high-voltage pulse is impressed across the entire bridge, and a balance is obtained by adjusting the variable arm. The null, or balance point, is indicated by the trace on an oscilloscope connected across the bridge at points diagonally opposite the high-voltage pulse connections.

A measure of the peak voltage of the pulses impressed across the test sample is obtained from the height of the trace on the screen of a second oscilloscope, calibrated in conjunction with a high-voltage attenuator.

With reference again to the diagram of Fig. 1, the two fixed arms

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MEASUREMENT
High Impulse Voltages

Commonly used methods of measuring resistance cannot predict the effect of voltage coefficient on resistors subjected to high impulse voltages. The decreased resistance caused by impulses such as ignition voltages can be determined by the technique described

By SCOTT L. SHIVE

Radio Engineer
Signal Corps Ground Signal Agency
Detroit Signal Laboratory
Detroit, Mich.

of the bridge circuit are 10,000 ohms and 100 ohms respectively. These are wire wound resistors which have zero voltage coefficient. The variable arm consists of a decade box, also of wirewound elements, whose setting at balance is exactly 1/100 of the test sample resistance. The null-point indicating oscilloscope used here is a 3 inch R.C.A. Model 155-A, while the pulse measuring system is composed of a DuMont oscilloscope, type No. 208, and a specially co-calibrated Rowe Research Laboratory high-voltage attenuator, type No. CA-211.

Operating Procedure and Precautions

After connecting the resistor sample into the bridge circuit, the output of the d-c supply is adjusted until the desired pulse voltage, as indicated on the pulse-measuring scope, is applied across the test sample. During this and the subsequent procedure, the pulses should be produced at a rate not exceeding one per second in order to avoid appreciable heating of the sample and in order that the capacitor may become completely charged between discharges, thus assuring identical amplitudes for successive pulses.

With the desired pulse voltage obtained, the decade box used as the variable arm of the bridge is adjusted to produce balance. For the particular fixed arm resistance values used herein, the resistance of the unknown test sample at the selected voltage is then 100 times the decade-box setting.

The bridge circuit is considered balanced for the setting at which the overall height of the trace on the null-point indicating oscilloscope is either zero or minimum. The height will be zero or nearly so when the test sample has little or no voltage coefficient, but for resistors with any appreciable degree of nonlinearity, the overall height of the trace cannot be reduced to zero and the null point becomes somewhat more difficult to detect.

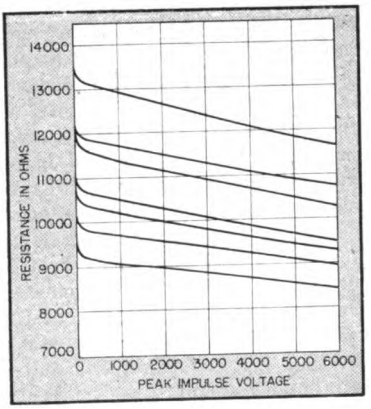

FIG. 2—Typical curves of resistance as a function of high impulse voltages, for samples of composition-type resistors. The nominal rating of the resistors is 10,000 ohms, one watt

Indicator Trace

The effect of voltage coefficient or nonlinearity is to introduce a third harmonic into the current wave in the side of the bridge circuit containing the sample. This harmonic, depending in amplitude upon the degree of the nonlinearity, appears in the voltage wave across the terminals of the null-point indicator and cannot be balanced out. Hence the balance point in this case is taken to be that at which the fundamental of the first half-cycle of the pulse wave train is balanced out, and nothing but harmonics remain in the oscilloscope trace. The fundamental is identified by a long tail extending well above or below the zero line and rapidly decreasing, as balance is approached from the high side, until finally at balance it disappears into the traces of the harmonics.

It will generally be found most satisfactory to operate the null-indicating oscilloscope with a horizontal sweep of approximately ½ inch and from 200 to 300 cps.

The fixed arms of the bridge may be composed of inductive wirewound resistors. The inductance so introduced has only a negligible effect on the accuracy of measurement at the frequency of the pulse wave. A 10,000 ohm wirewound resistor, with zero-voltage coefficient when measured at 10,000 volts, reads within 0.5 percent of its resistance at 6 volts d-c.

Typical Results

Figure 2 shows typical curves of resistance plotted against high impulse voltage obtained for representative samples of composition carbon-type suppressors nominally rated 10,000 ohms at one watt. The curves are seen to be relatively straight lines, from approximately 1,000 volts on up, with a constant negative slope. Thus for these samples, the resistance drop at high impulse voltages is approximately directly proportional to the peak value of voltage.

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MULTIPLE

By JOSEPH F. MANILDI

Chief Research Engineer
G. M. Giannini & Co., Inc.
Pasadena, California

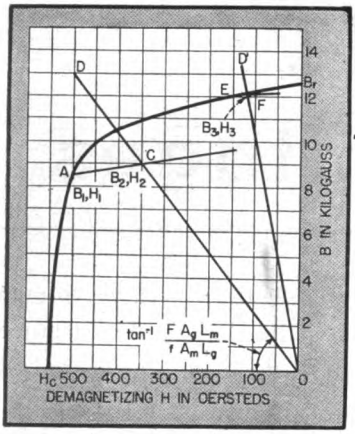

FIG. 1—Demagnetizing curve, Alnico V

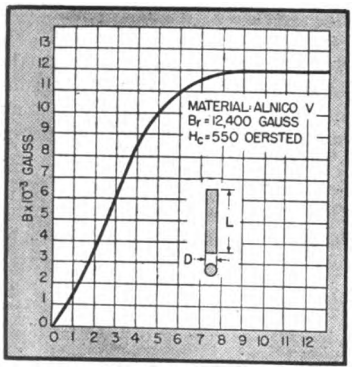

FIG. 2—Field intensity in a permanent magnet as a function of aspect ratio *L/D* (horizontal scale) for Alnico V

USE of parallel magnetic circuits rather than conventional single-magnet or series magnetic circuits results in many cases in a more efficient utilization of the magnetic material. By using parallel magnetic circuits, desired field strengths may be obtained in meters with less magnetic material, resulting in systems weighing less and occupying less space. This makes the method particularly useful in design of aircraft instruments, where space and weight limitations are important.

The method of design is particularly suited to cases where the magnetic circuit is subjected to open-circuit conditions or strong demagnetizing influences during its history, and it is necessary to make the magnetic system very stable. Considerable advantage is also obtained, however, in circuits which are not subjected to very severe demagnetizing influences.

The problem of efficiently designing a magnetic circuit has been thoroughly explored by present-day designers. Usually, however, design considerations are based upon a magnetic circuit in which the magnetomotive force is supplied by one or more magnets in series. Experimental data and analysis point to the fact that by using parallel magnetic circuits, a given field in an air gap may be obtained with considerably less magnetic material.

The fundamental problem is as follows: a given magnetic field is desired in an air gap of given area and length. What magnet design must be adopted to give a stable field of the stated value, using a minimum amount of magnetic material?

Underhill discusses the problem thoroughly[1] and gives design equations for a single series circuit. The problem of greatest interest is one where the magnets have been subjected to open-circuited conditions at one time or another. The design must be taken from this standpoint if a stable field is desired.

In the event that the magnetic circuit is not subjected to the demagnetizing influence of the air gap, the basic principles developed in the following analysis still continue to hold, and advantage is obtained in the use of parallel magnets. The advantages are more apparent in the case where the magnets are subjected to the equivalent of open-circuit conditions, however, and the analysis will be approached from that standpoint. We shall reiterate here the conditions which determine the design of a single series magnetic circuit, then show how it is modified by use of multiple circuits.

Resumé for Single Magnet

Referring to Fig. 1 which is the demagnetization portion of the *B-H* curve for a given material, when a bar or U magnet is magnetized to saturation then subjected to open-circuit conditions, its state is represented by point A on the curve, where the magnetic field and coercive force have the values B_1 and

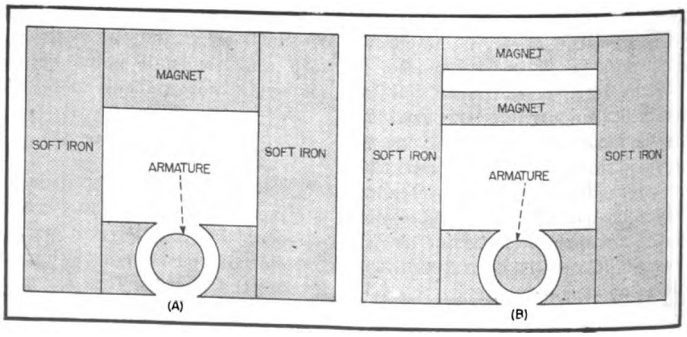

FIG. 3—Complete magnetic circuits employing a single series magnet (A) and four magnets in parallel (B; two magnets are behind those shown)

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MAGNETIC CIRCUITS

Small permanent magnets in parallel use less magnet material to produce a given field strength in an air gap, hence offer weight and space advantages in aircraft and other meters or synchros. Design equations and graphs give minimum magnet spacing

H, respectively. This point is determined by the L/D ratio of the magnet, where L = length of magnet, and D = effective diameter = $2\sqrt{\text{area}/\pi}$.

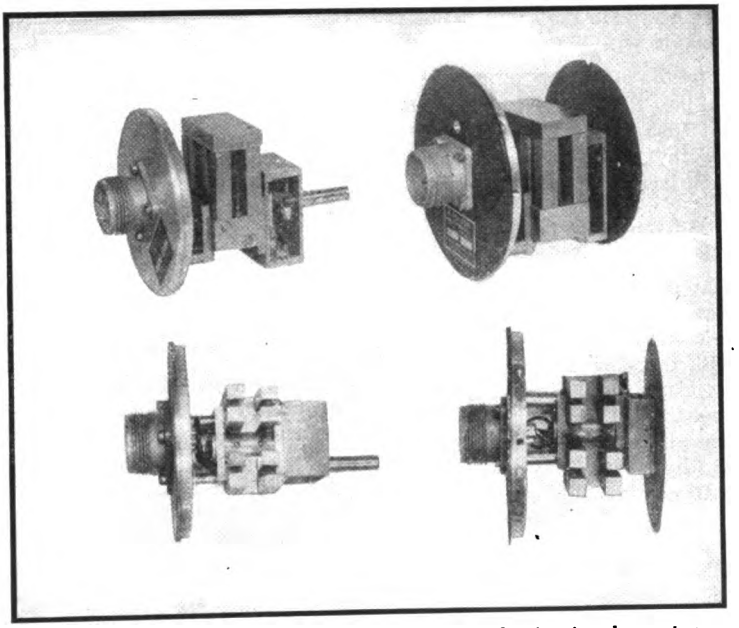
Figure 2 shows the relationship between L/D and B from which the point A may be determined for Alnico V (see Appendix A). When the magnet is placed in its magnetic circuit, complete with soft iron bridges, armature, and air gap, the state of the magnet is represented by point C in Fig. 1, which is the intersection of the minor hysteresis loop AC and the air-gap line OD. The minor hysteresis loop is determined from the fact that its slope is approximately parallel to the tangent to the B-H curve at the point B_r. The air-gap line is determined from the fact that its negative slope is equal[1] to FA_gL_m/fA_ml_g, where F and f are leakage factors depending on the configuration of the circuit, A_g is gap area, l_g is gap length, A_m is magnet cross-sectional area, and l_m is magnet length.

For a given magnet the necessary quantities are all known, and the point C may be determined either graphically or analytically. Thus, the value of B in the magnet is known, and the value of B in the air gap may be obtained from the relationship

$$B_g = A_m B_m / FA_g \qquad (1)$$

where B_g is the field in the gap and B_m is the field in the magnet given by the point C = B_c.

We can now show that if the magnet employed has an L/D less than about eight, a considerably higher field may be obtained in the air gap by using a multiple magnetic circuit. For specific illustration, let us assume that the magnetic circuit is the one shown in Fig. 3A, that the area of the magnet is A_m, that the L/D ratio is 4, and that the dimensions of the elements are such that the air-gap line is OD in Fig. 1. We see from Fig. 2 that $L/D = 4$ is represented by point A on the magnetization curve. Hence, after insertion into the circuit the point C represents the state of the magnet, and the field in the gap is given by Eq. (1).



Transmitter (left) and receiver (right) of a remote indicating impulse system employing parallel magnetic circuits to reduce weight as required for an aircraft application. Lower views have magnetic bridge removed to show arrangement of magnets more clearly

Four Magnets in Parallel

Now instead of the one magnet shown, let us use four magnets, as shown in Fig. 3B, each of which is the same length as the first, but whose cross-sectional areas are each one-fourth the original area. The diameters are now one-half the original diameter and $L/D = 8$. The total magnet area is unchanged, and total magnet volume is unchanged. We now place these magnets in close proximity in the magnetic circuit and proceed to calculate the new gap field.

We shall assume at this point that the proximity of the four magnets does not affect the relationship between B_m and L/D for each magnet. This assumption will be discussed in detail later. The open-circuit field is now given by point E on the curve. If we assume the leakage constants to be essentially unchanged, then the air-gap line for a single magnet has four times the slope, the air-gap line is OD′, and the field in the magnet when

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the magnetic circuit is complete is given by the point F, where the field in the magnet is B_3. The field in the air gap due to one magnet is now given by Eq. (1) and is equal to

$$B_g' = A_m' B_3/FA_g = A_m B_3/4 FA_g \quad (2)$$

where $A_m' = A_m/4$, the new cross-sectional area, and the field in the gap due to four magnets is parallel is given by

$$B_g'' = 4 B_g' = A_m B_3/FA_g \quad (3)$$

The field with the single magnet is equal to

$$B_g = A_m B_2/FA_g \quad (4)$$

Since $B_3 = 12{,}000$ gauss and $B_2 = 9{,}000$ gauss approximately, we see that the field in the gap has been increased by a factor of 1.33.

Advantages of Parallel Magnets

From the above analysis we see that if a single series circuit utilizes a magnet having $L/D<8$, the field in the gap may be increased with the same amount of material by using parallel magnets having an $L/D \geqq 8$. The value 8 is chosen since it is at the knee of the curve of Fig. 2.

It may readily be seen that if the most efficient series magnet for a particular design has an $L/D<8$, a larger field may be obtained by using parallel magnets having an $L/D \geqq 8$. This amounts to saying that the given field may be obtained, using parallel magnets, with less magnetic material than by using a single series circuit.

Design will be simplified by the fact that the open-circuit point will always be the point E. Furthermore, if it is desired to obtain a large field and the space is limited insofar as permissible length of magnet is concerned, many small magnets, all having an $L/D \geqq 8$, may be as effectively used as a longer magnet having the same mass of magnetic material.

The primary limitation on the effective use of parallel magnetic circuits arises from the fact that the parallelled magnets may not be brought too close to one another, since the adjacent magnets will tend to demagnetize each other.

The degree of proximity which may be imposed on a parallel magnet configuration, in order that maximum field may be obtained, can be determined by simple experiment and calculation.

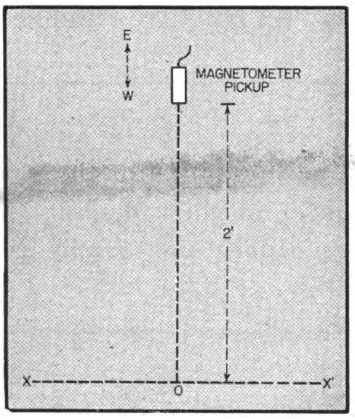

FIG. 4—Test arrangement for determining demagnetization of a permanent magnet as a result of another magnet placed in close proximity

Measurements

Test equipment consisted of a magnetometer, which was used to measure the flux from the test magnets. The test magnets consisted of 6 Alnico V magnets each 1 inch long and of square cross-section ¼ inch on each side. The magnetometer was adjusted to a sensitivity of 10 milligauss for a full-scale reading (30 divisions).

The magnetometer pickup was placed about two feet from the magnets to be tested, as shown in Fig. 4. The magnetometer measured field intensity, which is proportional to pole strength times length of magnet. Since the magnets were parallel to one another, the length of magnet was always 1 inch, and the indication was proportional to pole strength, which is in turn proportional to total flux emanating from the magnets.

TABLE I. Comparison of Strengths of Grouped Magnets With Predicted Strength of Equivalent Solid Magnets

No. of Magnets in Group	Total Pole Strength	Equivalent L/D	Predicted Strength of Solid Magnet
1	7.0	3.3	7.0
2	10.0	2.4	9.0
3	13.0	1.91	11.0
4	14.5	1.65	12.5
5	15.5	1.47	13.5
6	16.5	1.35	14.5

The distance between the magnetometer pickup and the magnet is sufficiently large so that moving the magnet three or four inches on either side along the line XX′ of position O has no effect on the reading of the magnetometer. This is essential to make an accurate determination of the proximity effect.

The six magnets were first individually magnetized and the pole strength of each was measured. Since the zero position of the magnetometer changed over a period of time because of extraneous fields in the region of the magnetometer, a reading was taken first with the south pole nearer the magnetometer, then with the north pole nearer the magnetometer. The total flux was taken as proportional to the average of the two readings.

The strengths of the individual magnets proved to be about the same, and equal to about seven units.

The magnets were then placed intimately side by side, like poles adjacent. First, two magnets were placed together and their combined strength measured, then a third magnet was added and the combined strength measured. This was continued until all six had been grouped. The results are shown in Fig. 5, along with the geometry of grouping. The demagnetizing effect is particularly noticeable. For one magnet the strength is 7, but for six magnets the strength is only 16.5, instead of 42 which would occur if no demagnetizing took place.

The magnets were then separated and individual strengths again measured. Each magnet now had only about half its original strength, indicating permanent demagnetization took place during grouping.

Proximity Effects

In order to determine how closely magnets can be grouped before the demagnetizing effect becomes noticeable, two magnets were placed along line XX' in Fig. 4 after having been freshly magnetized. They were placed 6 inches apart and 3 inches on each side of point O after their individual strengths had been determined. Readings of their combined

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strength as a function of their separation was taken. This data is plotted in Fig. 6.

It is to be noted that as the magnets are moved together, the combined strengths are about equal to the sum of the individual strengths until a separation of about ½ inch is attained, when the strength drops off. Data was taken first as the separation was decreased, then as it was increased again. The permanent demagnetizing effect is noticeable.

In order to obtain a quantitative measure of the extent of demagnetization when several magnets are grouped intimately, we must compare the strength of the group with the strength of a single magnet having the same length and cross-sectional area and shape. We may do this by use of Fig. 2, which shows the relationship between flux density and L/D ratio for Alnico V.

Using this curve and the strength of a single magnet, we may predict the strength of any magnet in the same material. Table I tabulates the experimental values plotted in Fig. 5 along with the predicted strength of solid magnets having the same length and cross-sectional area. Slightly greater strengths are obtained from the grouped magnets than from the solid magnet, but the difference is small. The curve for equivalent single magnet strengths is also plotted in Fig. 5.

Minimum Separation Distance

For the magnets tested, the smallest separation without serious demagnetizing effect is ½ inch center to center. This holds only for two magnets. The results may be approximately extended to groups of more than two magnets by considering that the limitation on the spacing arises from the field produced at the pole of one magnet by all the other magnets. Since the effect of all other poles is inversely proportional to the square of the distance from the pole under consideration, the pole under consideration will be subjected to the same demagnetizing influence from a group of magnets as from a single other magnet, assuming all magnets similar, if

$$\frac{1}{d_1^2} - \frac{1}{d_2^2} = \sum_i \left(\frac{1}{d_{1i}^2} - \frac{1}{d_{2i}^2} \right) \qquad (5)$$

where d_1 = distance of pole from the like pole in the two-magnet configuration
d_2 = distance of pole from the unlike pole in the two-magnet configuration
d_{1i} = distance of pole from like pole of the ith magnet of the multiple-magnet configuration
d_{2i} = distance of pole from unlike pole of the ith magnet of multiple-pole configuration

Thus, if the safe distances d_1 and d_2 are determined by test as outlined above for two magnets, the results can be used for determining safe spacings for any number of similar magnets in the group by use of Eq. (5). The summation must be performed on every magnet, of course, and the condition is that in each individual summation the right-hand side of Eq. (5) must be less than or equal to the left-hand side.

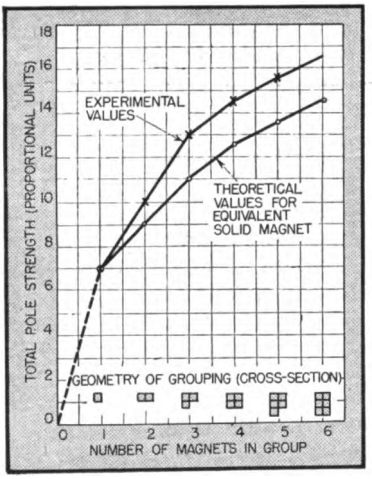

FIG. 5—Combined pole strength of magnets grouped in intimate contact

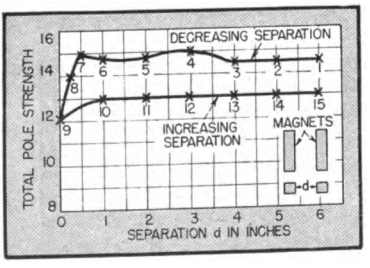

FIG. 6—Combined pole strength of two magnets as a function of their separation. Individual strengths of magnets are equal to 7.5 Plotted points are numbered in the order in which measurements were made

Conclusions

On the basis of the analytical and experimental evidence presented above, it appears that parallel magnetic circuits can be effectively used in instruments operating by virtue of a magnetic field in a gap.

In each individual instance, care must be taken that the individual parallel magnets shall not be placed too close to one another in the parallel circuit. However, the critical spacing distance is not very large in ordinary instances, and this feature does not present an undesirable limitation.

In particular, advantage can be taken of the above design principles in instruments where the L/D ratio for the magnet in the single-magnet circuit is less than 8. The net result of such design is the obtaining of the desired field with less magnetic material and a field which is more stable to demagnetizing influence.

Appendix A. Determination of Relationship Between B and L/D for Single Open-circuited Bar Magnet

We shall use an approximate parabolic equation for the demagnetizing portion of the hysteresis curve for Alnico V[1]

$$B = \frac{B_r (H_c - H)}{H_c - aH} \qquad (6)$$

where B_r is residual flux density, H_c is coercive force, and a is a constant related to the magnet material. An empirical equation relating the ratio of B to H for a permanent bar magnet[1] then is

$$\frac{B}{H} = (1.89 - a) \left(\frac{L}{D} + a \right)^{1.82} \qquad (7)$$

We now obtain a relationship between B and L/D

$$\frac{B(B_r - aB)}{H_c (B_r - B)} = (1.89 - a) \left(\frac{L}{D} + a \right)^{1.82} \qquad (8)$$

Equation (7) and hence Eq. (8) is invalid for $L/D < 1$, but this need not concern us since we know from physical considerations that when $L/D = 0$, $B = 0$. Using $B_r = 12{,}400$ gauss and $H_c = 550$ oersteds,

$$a = 2\sqrt{\frac{B_r H_c}{B_c H_c}} - \frac{B_r H_c}{B_c B_c} = 1.51$$

where B_c and H_c are coordinates of the maximum-energy point. The curve shown in Fig. 2 is obtained from Eq. (8).

Reference

(1) Underhill, Earl M., Designing Stabilized Permanent Magnets, ELECTRONICS, Jan. 1944, p. 118.

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Resistance-Capacitance FILTER CHART

Values of R and C for both low-pass and high-pass filters are given in terms of the amount of rejection desired at any given frequency from 1 millicycle to 1,000 megacycles. Chart also gives the reactance of a capacitor at any frequency

By ERNEST FRANK

Sperry Gyroscope Co.
Garden City, N. Y.

RESISTANCE-CAPACITANCE filters are frequently used when a sharp cutoff characteristic is not required and, in the low-pass case, when the voltage drop across the series resistor can be tolerated. Applications of the low-pass R-C filter include decoupling from a common power supply for a multistage vacuum-tube amplifier, smoothing filters for power supplies when a large voltage drop across the filter is not objectionable, and inexpensive hash filters to attenuate high-frequency disturbances on electrical leads. High-pass R-C filters are often used as interstage coupling networks.

The circuits of Fig. 1 show the R-C low-pass and high-pass filter connected to an a-c generator. The generator resistance is assumed to be negligible compared with R, and d-c voltages are omitted for the purposes of an a-c analysis. R and C form a voltage divider, and the complex output voltage is given by

$$\text{Low-pass: } E_o = \frac{-jX_cE_i}{R - jX_c} \qquad (1a)$$

$$\text{High-pass: } E_o = \frac{RE_i}{R - jX_c} \qquad (1b)$$

The magnitude of the ratio of E_i to E_o is

$$\text{Low-pass: } \left|\frac{E_i}{E_o}\right| = \sqrt{1 + \left(\frac{R}{X_c}\right)^2} \qquad (2a)$$

$$\text{High-pass: } \left|\frac{E_i}{E_o}\right| = \sqrt{1 + \left(\frac{X_c}{R}\right)^2} \qquad (2b)$$

Solving the above equations for the generator frequency f gives

$$\text{Low-pass: } f = \frac{1}{2\pi RC}\sqrt{\left|\frac{E_i}{E_o}\right|^2 - 1} \qquad (3a)$$

$$\text{High-pass: } f = \frac{1}{2\pi RC}\frac{1}{\sqrt{\left|\frac{E_i}{E_o}\right|^2 - 1}} \qquad (3b)$$

When the reactance of C is equal to R, the ratio $|E_i/E_o|$ is equal to $\sqrt{2}$. This condition occurs at a frequency f_s that is equal to $1/2\pi RC$ and corresponds to the frequency at which the output voltage is 3 db down from the input voltage, ignoring impedance levels (db = 20 $\log_{10}|E_o/E_i|$). Therefore

$$\text{Low-pass: } f = f_s\sqrt{\left|\frac{E_i}{E_o}\right|^2 - 1} \qquad (4a)$$

$$\text{High-pass: } f = f_s\frac{1}{\sqrt{\left|\frac{E_i}{E_o}\right|^2 - 1}} \qquad (4b)$$

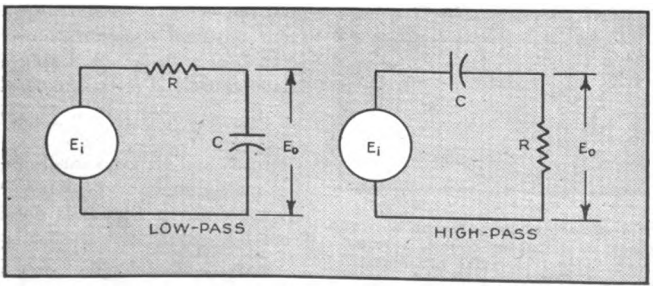

FIG. 1—Low- and high-pass R-C filters shown connected to a-c generator

In low-pass applications the ratio $|E_i/E_o|$ is often selected to be 10 or greater. Therefore, Eq. (4a) becomes

$$f \simeq f_s\left|\frac{E_i}{E_o}\right| \quad ; \quad \left|\frac{E_i}{E_o}\right| \gtrsim 10 \qquad (5)$$

because $|E_i/E_o|^2 \gg 1$. The value of f is given to an accuracy of about 1 percent by Eq. (5) when $|E_i/E_o| = 10$. When $|E_i/E_o| = 100$, f is given to an accuracy of about 0.1 percent. The error resulting from the use of Eq. (5) is in the pessimistic direction since the true value of f, obtained from Eq. (4a), is always smaller than the value of f given by Eq. (5).

Use of Chart

In high-pass applications, the value of f_s is usually of primary interest, and is given by $f_s = 1/2\pi RC$. The chart in Fig. 2 enables f_s to be read directly in one operation for a given value of R and C in either the low-pass or high-pass case. When a value of $|E_i/E_o|$ equal to or greater than 10 is desired in the low-pass case, the value of f_s determined from the chart can be multiplied by $|E_i/E_o|$. The chart can also be used to determine the reactance of a capacitor at any frequency. The following examples illustrate the use of the chart.

Example 1

A plate decoupling R-C filter must attenuate frequencies above 50 cps by a voltage ratio of 10:1. The value of R cannot exceed 4,000 ohms to avoid an excessive loss in d-c voltage. What value of C is required? From Eq. (5), $f_s = 50/10 = 5$ cps. From the chart, draw a

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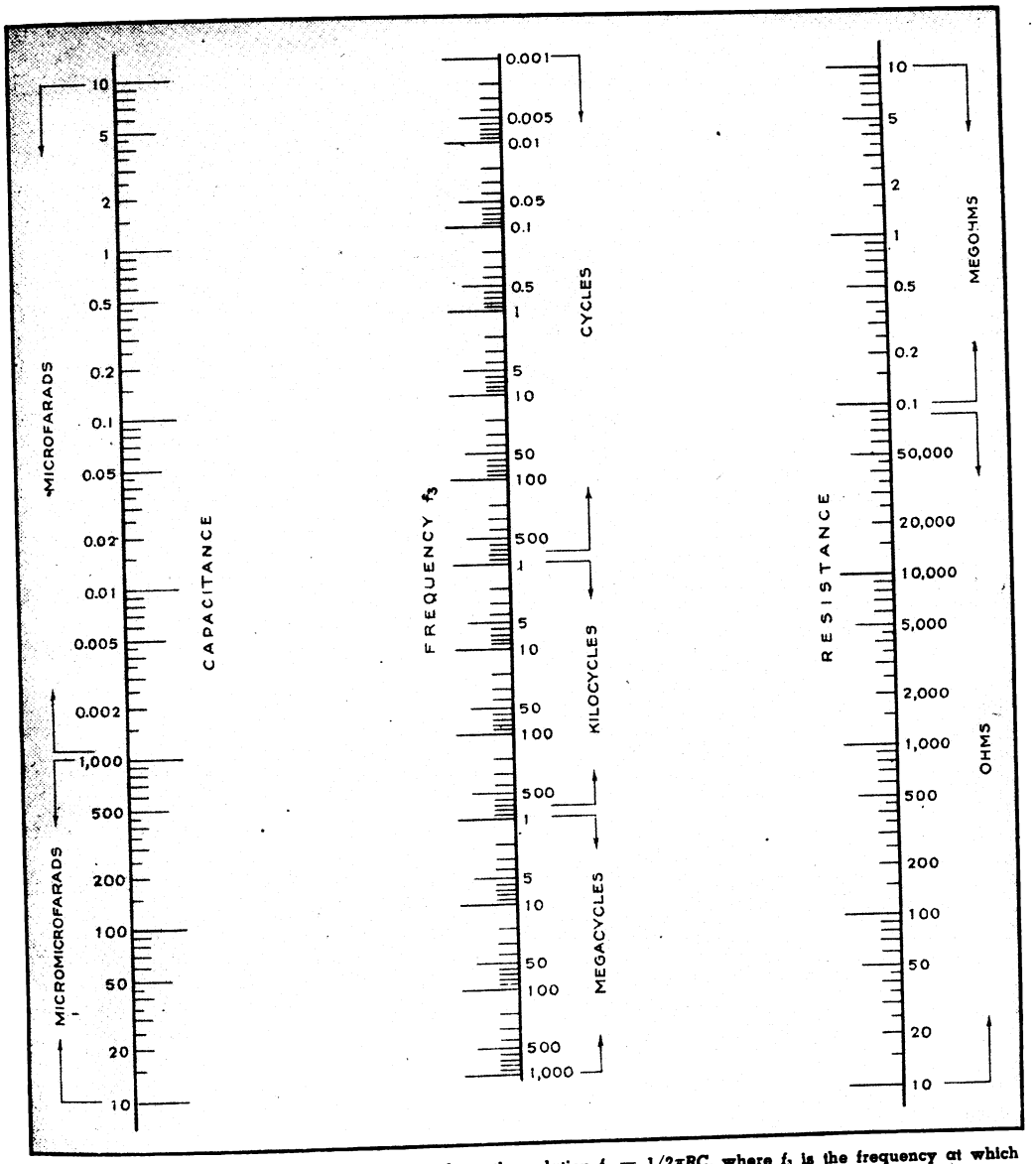

FIG. 2—Resistance-capacitance filter chart based on the relation $f_s = 1/2\pi RC$, where f_s is the frequency at which the filter provides an attenuation of 3 db. To find the reactance of a capacitor, place ruler on known capacitance and frequency values and read the reactance value on the resistance scale

line through $f_s = 5$ cps and $R = 4{,}000$ ohms. Read $C = 8\mu$f.

Example 2

The low-frequency end of the 3-db pass-band of a resistance-capacitance coupled amplifier must be 100 cps. A 0.01-μf coupling capacitor is available. What value of output resistance must be used? Draw a line through $C = 0.01$ μf and $f_s = 100$ cps. Read $R = 0.16$ meg.

Example 3

What is the reactance of a 0.002-μf capacitor at 1 megacycle? Draw a line through $C = 0.002$ and $f_s = 1$ mc, and determine $R = 80$ ohms.

Construction of Chart

The chart covers a wide range at the sacrifice of accuracy in readability. If greater accuracy is desired, it is simple to construct a chart which covers a limited range.

1. Use two sheets of log paper, one of which has twice as many cycles as the other; for instance, two-cycle and four-cycle paper. Each complete scale must be the same total length.

2. On opposite edges of the two-cycle paper, write down the resistance and capacitance values including the desired range.

3. Cut a strip of the four-cycle paper and prepare to paste it equidistant from, and parallel to, the R and C scales, in an inverted sense.

4. Compute f_s for one value of R and C included on the scales.

5. Match the four-cycle frequency scale to the line joining these values of R and C and paste the scale in place.

6. Label the frequency scale, using the computed value of f_s as a guide to the major scale values.

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SINGLE-SIDEBAND GENERATOR

Balancing out the undesired sideband in a vacuum-tube circuit eliminates need for highly selective filters in power-line carrier systems for telemetering or voice communication

By M. A. HONNELL

Associate Professor of Electrical Engineering
Georgia School of Technology
Atlanta, Georgia

A COMPARISON of a-m, f-m, and single-sideband systems for power-line carrier transmission appeared recently in the literature.[1] To the writer's knowledge, most single-sideband systems require the use of highly selective filters and, in some cases, require a double modulation process to separate the sidebands sufficiently for effective filtering.

Basic Theory

There is another approach to the problem of generating single-sideband signals which appears not to have been exploited. This system makes the use of highly selective filters unnecessary, because the undesired sideband is balanced out in a vacuum-tube circuit.

An examination of the equations for amplitude-modulated signals in Table I reveals some interesting possibilities.[2] Let us consider the following pair of equations for an amplitude-modulated signal

$$\sin A\ (1 + m \cos B) =$$

$$\sin A + \frac{m}{2}\sin(A-B) + \frac{m}{2}\sin(A+B) \quad (1)$$

$$\cos A\ (1 + m \sin B) =$$

$$\cos A - \frac{m}{2}\sin(A-B) + \frac{m}{2}\sin(A+B) \quad (2)$$

where

$A = 2\pi f_c t$
$B = 2\pi f_s t$
m = modulation factor

If the amplitude-modulated signals are generated in a balanced modulator[3], the carriers are readily eliminated, and the resulting signals at the output of the balanced modulators are of the form

$$G \sin(A+B) + G \sin(A-B) \quad (3)$$
$$G \sin(A+B) - G \sin(A-B) \quad (4)$$

where G is the modulator conversion gain.

It is apparent that if these signals are added, the resultant is the upper sideband, while if they are subtracted the resultant is the lower sideband.

The Practical System

The block diagram of a system constructed to generate a single sideband using this technique is shown in Fig. 1. An examination of Eq. (1) and (2) and Fig. 1 reveals that the carrier as well as the signal frequencies must be shifted 90 degrees in order to obtain the desired phase relations. This is readily achieved in the case of the fixed carrier frequency

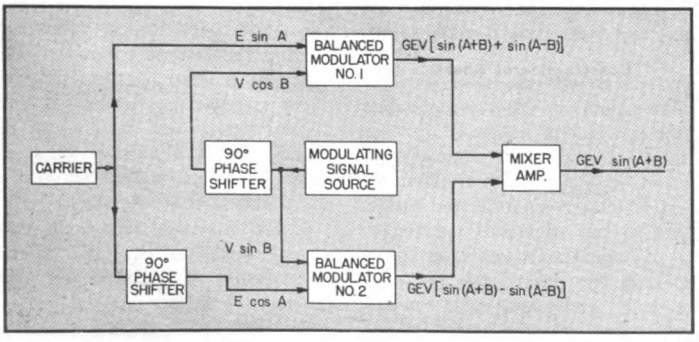

FIG. 1—Block diagram of single-sideband generator using two balanced modulators. The mixer is a linear amplifier

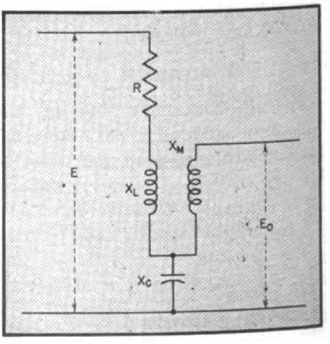

FIG. 2—Schematic circuit diagram of the 90-degree phase shifter

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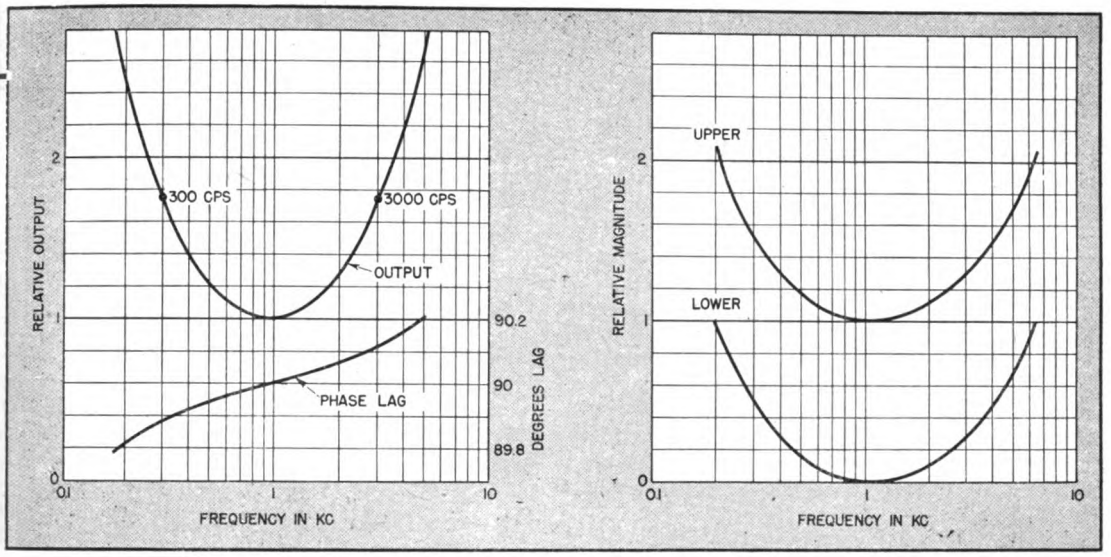

FIG. 3—Calculated amplitude and phase response of phase shifter with $R = 100{,}000$ ohms, $C = 2.34$ microfarads, and $L = M = 0.012$ henry

FIG. 4—Measured relative magnitudes of upper and lower sidebands, plotted as a function of the modulating frequency of the system

through the use of a simple phase shifter.[4] If the modulating signals are one or more fixed telemetering frequencies, the required 90-degree phase shifts for these frequencies may be obtained by using a phase shifter of the resistor-capacitor type.

90-Degree Phase Shifter

The problem of shifting a band of telephonic voice frequencies of from 300 to 3,000 cycles is inherently more difficult. It is necessary, in the ideal case, to shift this band of frequencies 90 degrees and at the same time leave the relative magnitudes unchanged. The necessary sine-cosine relationship can be obtained electronically by using an additional pair of modulators and a simple filter.

A passive network which gives a reasonable approach to this problem is shown in Fig. 2, while its amplitude and phase response characteristics are shown in Fig. 3. The amplitude response of this phase shifter is

$$\frac{E_o}{E} = \frac{X_C + X_M}{\sqrt{R^2 + (X_L - X_C)^2}} \qquad (5)$$

When R is much greater than $(X_L - X_C)$, this becomes very closely

$$E_o/E = (X_C + X_M)/R \qquad (6)$$

The phase response of the network is

$$\phi = -90° - \tan^{-1}(X_L - X_C)/R \qquad (7)$$

Referring to Fig. 3, it is seen that the amplitude response varies through a range of 1.75/1 over the frequency band of 300 to 3,000 cps. While this variation is undesirable in an ideal system, it is compensated in part through the use of an output tuned circuit resonated to the mid-frequency of the desired sideband. In addition, this response characteristic partially corrects for the frequency discrimination due to the usual microphones, receivers and speech-band repeat coils.

System Performance

The single-sideband generator outlined in Fig. 1 and using the phase shifter of Fig. 2 was constructed to check the possibilities of the proposed system. A carrier frequency of 8,000 cps was chosen in order that all frequencies through the second harmonic of the carrier would fall within the range of a standard harmonic wave analyzer.

Balanced square-law modulators were used, and since the experimental system contained no filters or tuned circuits, it was necessary to make the carrier amplitude much greater than the signal amplitude so that the residue of the signal would be negligibly small at the output of the modulators.[5] Although the second harmonic of the carrier at the output of each balanced mod-

TABLE I. EQUATIONS OF AMPLITUDE-MODULATED WAVES

$$\sin A\,(1 \pm m \sin B) = \sin A \pm \frac{m}{2}\cos(A - B) \mp \frac{m}{2}\cos(A + B$$

$$\sin A\,(1 \pm m \cos B) = \sin A \pm \frac{m}{2}\sin(A - B) \pm \frac{m}{2}\sin(A + B)$$

$$\cos A\,(1 \pm m \sin B) = \cos A \mp \frac{m}{2}\sin(A - B) \pm \frac{m}{2}\sin(A + B)$$

$$\cos A\,(1 \pm m \cos B) = \cos A \pm \frac{m}{2}\cos(A - B) \pm \frac{m}{2}\cos(A + B)$$

where $A = 2\pi f_c t$
$B = 2\pi f_s t$
f_c = carrier frequency
f_s = modulating signal frequency

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ulator is quite large, it is cancelled when the outputs of the two modulators are combined in the mixer amplifier.

Figure 4 shows the measured magnitudes of upper and lower sidebands, plotted as a function of the modulating frequency and normalized about the 1,000-cps value of the upper sideband. These experimental values check very closely with the expected magnitudes on the basis of the calculated response of the phase shifter as shown in Fig. 3.

Referring to Fig. 4, it is to be noted that for an 8,000-cps carrier the 1,000-cps point on the upper-sideband curve represents a sideband frequency of 9,000 cps, whereas the corresponding point on the lower-sideband curve represents a frequency of 7,000 cps. A parallel-resonant circuit or a simple double-tuned coupled circuit tuned to 9,000 cps and placed in the output of the mixer amplifier of Fig. 1 will flatten the upper-sideband curve and will discriminate against the lower-sideband frequencies.

Figure 5 shows the measured upper- to lower-sideband ratios plotted in decibels as a function of the modulating frequency. It is to be noted that this ratio exceeds 10 db from 300 to 3,000 cps. The data for the plotted curves was obtained on the single-sideband generator shown in Fig. 6, containing no filters or tuned circuits and practically no shielding. The results represent, therefore, the most pessimistic of operating conditions. For carrier transmission or for radio transmission, simple tuned circuits would be employed in the amplifiers following the mixer amplifier, with a resultant improvement in discrimination against the undesired sideband.

If it is desired to pass the lower sideband and to balance out the upper sideband, this is accomplished by reversing the polarity of either the carrier or the signal voltage fed to one of the modulators. This result may also be achieved by reversing the polarity of the output voltage of one of the modulators. Measured characteristics for this case are similar to Fig. 4 and 5.

The characteristics of this particular system do not represent the optimum performance that can be obtained from a single-sideband generator of this type. In the opinion of the writer, this generator has the advantage of simplicity over the usual single-sideband systems. The complete success of the system lies in the design of a wide-band 90-degree phase shifter. However, it is to be remembered that a simple 90-degree phase shifter suffices if the modulating signals are fixed telemetering frequencies.

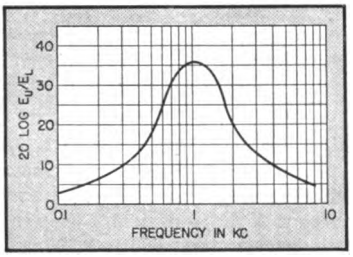

FIG. 5—Measured upper to lower sideband ratios in db

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(4) M. I. T. EE Staff, "Applied Electronics," *John Wiley & Sons, Inc.*, 1943, p. 316–319.
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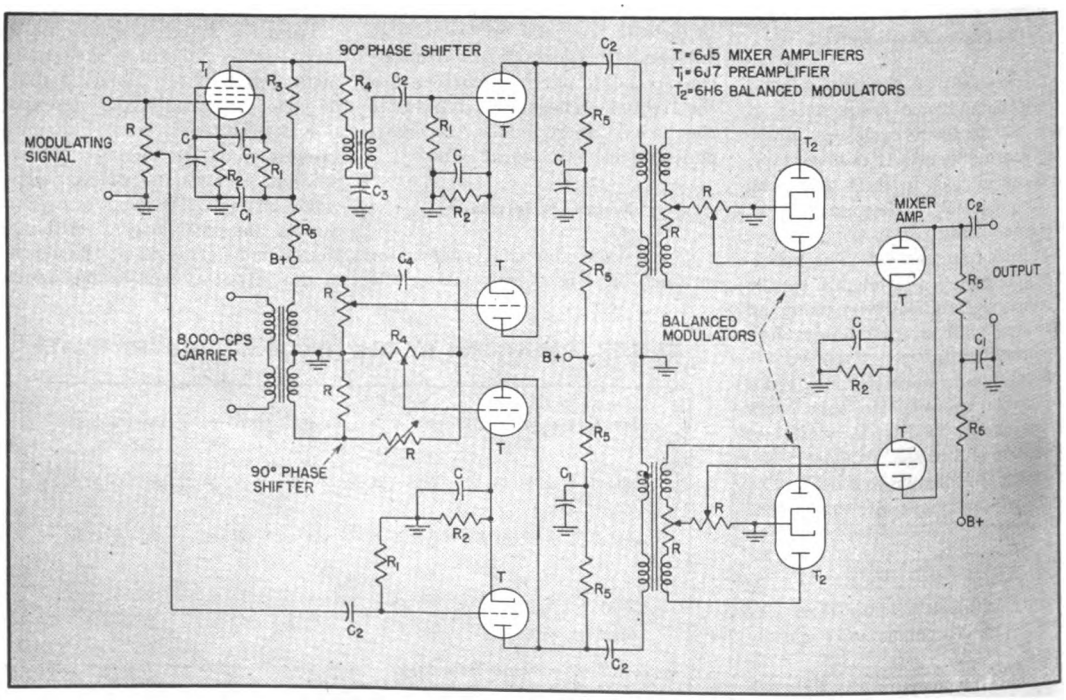

FIG. 6—Circuit of experimental single-sideband generator

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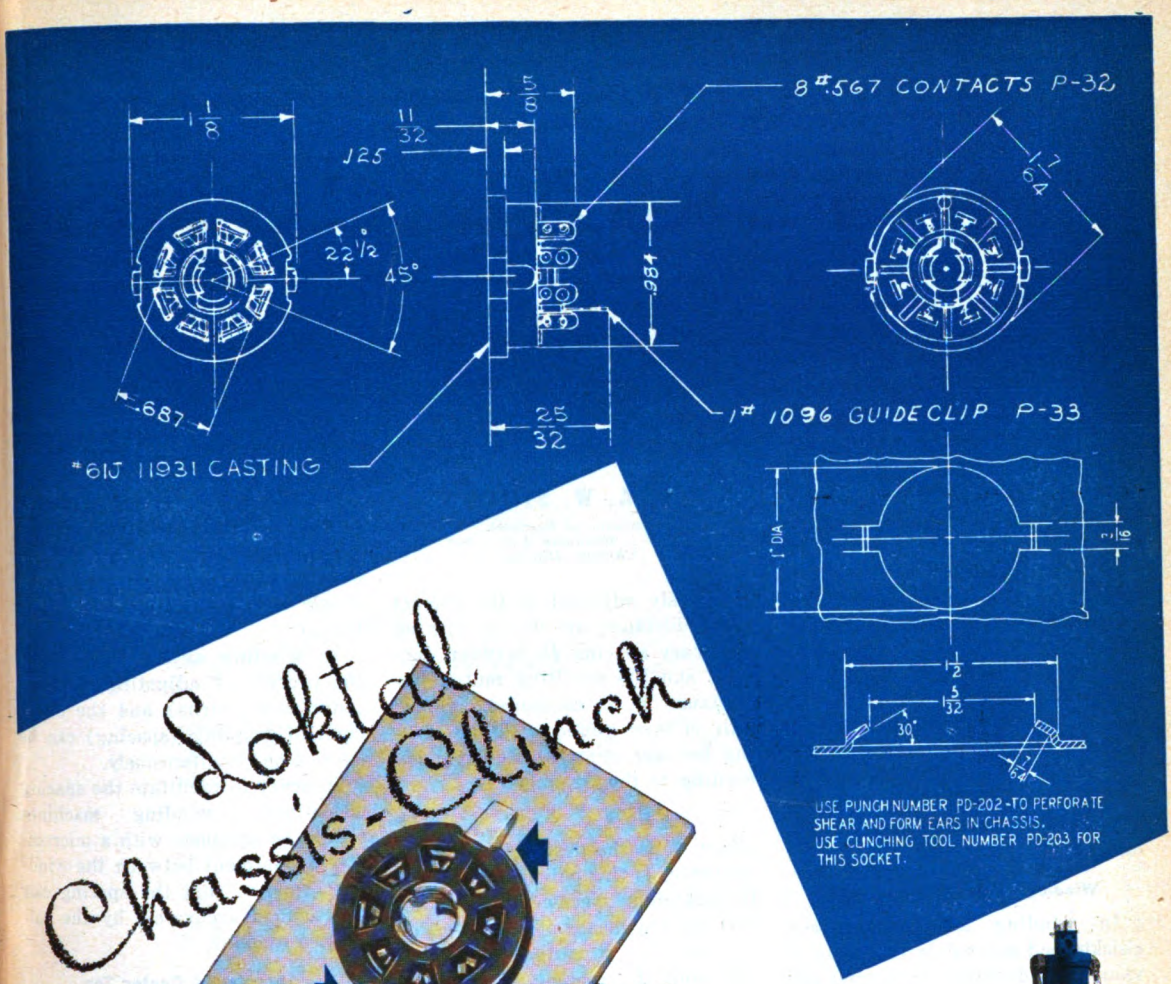

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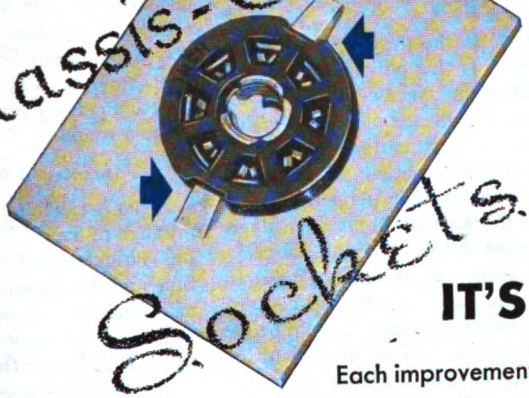

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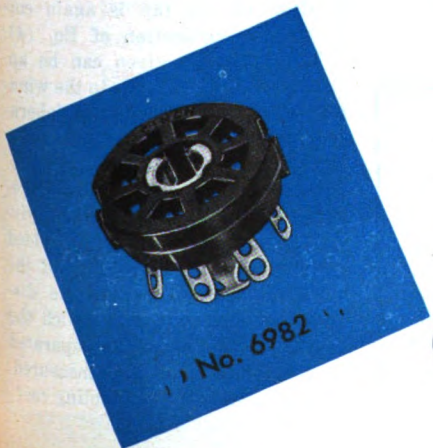

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Winding UNIVERSAL COILS

Short-cut procedures for winding sample universal coils quickly to exact self-inductance, spacing coils to exact mutual inductance, and taking out a center tap accurately

By A. W. SIMON

Director of Research
Edwin I. Guthman & Co., Inc.
Chicago, Illinois

IN winding a universal coil to a given value of inductance, the usual procedure is to wind or unwind turns, more or less by guess, until the desired inductance has been attained. A somewhat similar procedure is followed in adjusting the spacing between two coils to produce a desired mutual inductance or coefficient of coupling, and in taking out a center tap. However, in all these cases it is possible to set up procedures which will lead directly and rapidly to the desired result.

Winding to Exact Inductance

In winding a universal coil quickly and accurately to a desired value of inductance L, a trial coil is first wound with an arbitrary number of turns T_1 and the resulting inductance L_1 is measured. A new coil is then wound with the number of turns T calculated according to the formula

$$T = T_1\sqrt{L/L_1} \qquad (1)$$

and measured. If this coil is not correct, the number of turns is again corrected by means of Eq. (1). Even though the initial number of turns is far from correct, it is not necessary usually to wind more than a few coils before the desired inductance is obtained exactly.

Another procedure involves changing the number of turns by half the fractional part (or percentage) by which the inductance deviates from the desired value. For example, if the inductance is 10 percent high, the number of turns is decreased by 5 percent.

Spacing to Exact Mutual Inductance

Two parallel coaxial coils, each previously adjusted to the correct self-inductance, are wound with an arbitrary spacing D_1 between centers, and the resulting mutual inductance M_1 is measured. A new pair is then wound with the spacing between centers calculated according to the formula:

$$D = D_1\sqrt{M_1/M} \qquad (2)$$

where M is the desired mutual inductance. If this pair is not correct, the spacing between centers is again corrected by means of Eq. (2). The alternative procedure involves changing the spacing by half the fractional part (or percentage) by which the mutual inductance deviates from the desired value.

The same process can be used to adjust the spacing between centers of two parallel coaxial coils in order to produce a desired coefficient of coupling k. The formula is:

$$D = D_1\sqrt{k_1/k} \qquad (3)$$

It is more convenient to work with the coefficient of coupling since the coils need not be adjusted exactly to the correct self-inductance. For constant spacing, k for parallel coaxial universal coils varies only slowly with turns (with self-inductance).

In winding an i-f transformer the process of adjusting the self-inductance (turns) and the coefficient of coupling (spacing) can be carried on simultaneously.

In order to facilitate the spacing adjustment, winding machines should be equipped with a micrometer adjustment between the winding arms, so that the spacing can be changed accurately by the calculated amount.

Locating a Center Tap

A tap is taken out at an arbitrary number of turns T_1 and the resulting inductance $L_{1\text{-}2}$ from start to tap, and $L_{2\text{-}3}$ from tap to finish, is measured. A new coil is then wound with a tap taken out at a number of turns T given by the formula:

$$T = T_1\sqrt{(L_{1\text{-}2} + L_{2\text{-}3})/2L_{1\text{-}2}} \qquad (4)$$

If the new coil is not correct, the location of the tap is again corrected by application of Eq. (4).

The formulas given can be applied profitably not only to the winding of sample coils in the laboratory, but also to the continuous control of coils in production. For production a table or chart can be prepared for each coil being run, giving the number of turns to be added or subtracted as a function of the measured inductance, or the distance in thousandths by which the winding arms must be separated as a function of the measured mutual inductance or coupling coefficient.

Universal coils, widely used in modern radio receivers, are wound so that as the dowel or form rotates, the wire is guided back and forth by a shuttle that displaces the wire in linear proportion to the angle of rotation from the point of maximum left or right displacement. Details of how to calculate the various factors entering into the winding of these coils were given by the author in ELECTRONICS, Oct. 1936, p. 22.

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The electronics BUYERS' GUIDE

First Postwar Directory of ELECTRONIC and ALLIED PRODUCTS

In the preparation of this year's Directory every possible effort has been made to include the names and product listings of all manufacturers (new or old) of electronic components or complete equipment, as well as those whose products have any application in the electronic field.

This listing includes all postwar products, as far as the companies themselves could accurately determine. The directory therefore should prove extremely useful as a valuable source of information to design engineers and buyers for all products that will be available in the coming year.

More than 3,000 companies and their complete product lines in electronic fields are listed, arranged and indexed in a simple, easy-to-read manner. Wherever possible, manufacturers' lines have been broken down to show various types produced.

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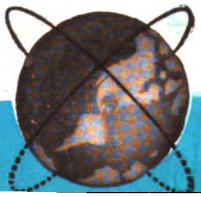

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Adapters

TEST ADAPTERS

Adrem Co., 143 Newberry St., Boston 16, Mass.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway South, Mt. Vernon, N. Y.
Dayton Acme Co., 930 York St., Cincinnati, Ohio
General Electric Co., Schenectady 5, New York
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
J. F. D. Mfg. Co., 4111 Ft. Hamilton Pkwy., Brooklyn, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lewyt Corp., 60 Broadway, Brooklyn, N. Y.
McDanel Refractory Porcelain Co., 510 Ninth Ave., Beaver Falls, Pa.
Radio City Products Co., 127 W. 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Readrite Meter Works, College Ave., Bluffton, Ohio
Stedman, Robert L., Oyster Bay, N. Y.
Stokes Rubber Co., Jos., Taylor & Webster Sts., Trenton, N. J.
Triplett Electrical Instrument Corp., 286 Harmon Rd., Bluffton, Ohio
Wood Electric Co., Inc., C. D. 826 Broadway, New York 3, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

Aircraft Relays

see Relays, Sensitive Control

Aluminum

see Metals

Ammeters

see Meters

Amplifiers

AUDIO FREQUENCY AMPLIFIERS

Air Associates, Inc., 5827 W. Century Blvd., Los Angeles 45, Calif.
Airdesign & Fabrication Inc., 241 Fairfield Ave., Upper Darby, Pa.
Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kans.
Altec Lansing Corp., 1680 North Vine St., Los Angeles 28, Calif.
American Communications Corp., 306 Broadway, New York, N. Y.
American Radio Co., 611 W. Garfield Ave., Glendale, Calif.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Arrow Radio Co., 900 W. Jackson Blvd., Chicago, Ill.
Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Aviometer Corp., 370 W. 35th St., New York 1, N. Y.
Baldwin Locomotive Works, Eddystone, Pa.
Ballantine Laboratories, Inc., Boonton, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bell Sound Systems, Inc., 1183 Essex Ave., Columbus, Ohio
Bogen Co., David, 663 Broadway, New York 12, N. Y.
Bunnell & Co., J. H., 215 Fulton St., New York, N. Y.
Carrillitone Mfg. Co., 30 N. Penn St., York, Pa.
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Chicago Transformer Div., Essex Wire Corp., 3501 West Addison St., Chicago 18, Ill.
Cincinnati Time Recorder Co., 1733 Central Ave., Cincinnati, Ohio
Collins Radio Co., 855 35th St., N.E., Cedar Rapids, Iowa
Commercial Research Labs. Inc., 20 Bartlett Ave., Detroit, Mich.
Communication Equipment & Engrg. Co., 504 N. Parkside Ave., Chicago, Ill.
Communications Equipment Corp., 134 W. Colorado St., Pasadena 1, Calif.
Consolidated Engineering Corp., 595 E. Colorado St., Pasadena 1, Calif.
DeMornay-Budd, Inc., 475 Grand Concourse, New York, N. Y.
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Eastern Amplifier Corp., 794 E. 140 St., Bronx 54, New York
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eckstein Radio & Television Co., 914 La Salle Ave., Minneapolis 2, Minn.
Electro Engineering & Mfg. Co., 627 W. Alexandrine Ave., Detroit, Mich.
Electronic Corp. of America, 45 West 18th Street, New York 11, N. Y.
Electronic Supply Co., 207 Main St., Worcester, Mass.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Fairchild Camera & Instrument Corp., 475 Tenth Ave., New York 18, N. Y.
Farrand Optical Co., Inc., Bronx Blvd., 238th St., New York 66, N. Y.
Federal Instrument Co., 3931 47th St., Long Island City 4, N. Y.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Foote Pierson & Co., Inc., 75 Hudson St., Newark 4, N. J.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, New York
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gibbs & Co., Thomas B., Div. of Borg Corp., George W., 814 Michigan St., Delavan, Wisc.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb.
Gray Mfg. Co., 16-30 Arbor St., Hartford, Conn.
Guided Radio Corp., 161 Sixth Ave., New York 13, N. Y.
Harvey Radio Labs., Inc., 447 Concord Ave., Cambridge, Mass.
Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Hatry & Young, 203 Ann St., Hartford, Conn.
Hearing Aid Labs., 1404 Franklin St., Michigan City, Ind.
Henney Motor Co., Gentlemen Prod. Div., Freeport, Ill.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
Howard Radio Co., 1735 Belmont Ave., Chicago 13, Ill.
Hudson American Corp., 25 West 43rd St., New York, N. Y.
Industrial Sound Products Co., 3597 Mission St., San Francisco, Calif.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Knickerbocker Development Co., 116 Little St., Belleville 9, N. J.
Langevin Co., Inc., 37 W. 65th St., New York, N. Y.
Lincrophone Co., 1661 Howard Ave., Utica, N. Y.
Madison Electrical Products Corp., Madison, New Jersey
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Meck Industries, John, Liberty St., Plymouth, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Miller Corp., Wm., 362 W. Colorado St., Pasadena, Calif.
Minerva Corp. of America, 238 William St., New York 7, N. Y.
National Co., 61 Sherman St., Malden 48, Mass.
National Electronic Mfg. Corp., 22-78 Steinway Street, Long Island City 5, N. Y.
National Scientific Products Co., 5013 N. Kedzie Ave., Chicago 25, Ill.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Newcomb Audio Products Co., 2815 S. Hill St., Los Angeles 18, Calif.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Operadio Mfg. Co., St. Charles, Ill.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Paraphone Hearing Aid, Inc., 2056 E. 4th St., Cleveland 15, Ohio
Powers Electronic & Communication Co., New Street, Glen Cove, L. I., N. Y.
Press Wireless Inc., Hicksville, L. I., N. Y.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Radell Corp., 6323 Guilford Ave., Indianapolis, Ind.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Craftsmen, 1341 South Michigan Ave., Chicago 5, Ill.
Radio Laboratories, Inc., 2701 California Ave., Seattle 6, Wash.
Radio Mfg. Engineers, Inc., 304 First Ave., Peoria, Ill.
Radolek Co., 601 W. Randolph St., Chicago 6, Ill.
Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Red Arrow Electric Corp., 100 Colt St., Irvington, N. J.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Rek-O-Kut Co., 173 Lafayette St., New York 13, N. Y.
Remler Company, Ltd., 2101 Bryant St., San Francisco 10, Calif.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Rosen & Co., Raymond, 32nd & Walnut Sts., Philadelphia 4, Pa.
Rowe Radio Research Laboratory, 2422 N. Pulaski Rd., Chicago 39, Ill.
SOS Cinema Supply Co., 449 W. 42nd St., New York 18, N. Y.
Sanborn Co., 39 Osborne St., Cambridge 39, Mass.
Schulmerich Electronics Co., Sellersville, Pa.
Schuttig & Co., 9th & Kearney Sts., N. E., Washington 17, D. C.
Setchell Carlson, Inc., 2233 University Ave., St. Paul 4, Minn.
Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y.
Simpson Mfg. Co., Inc., Mark, 188 W. Fourth St., New York, N. Y.
Sonora Radio & Television Corp., 2626 W. Washington St., Chicago 28, Ill.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Sound Equipment Corp. of California, 3903 San Fernando Road, Glendale 4, Calif.
Springfield Sound Co., Electronics Division, 12 Cass St., Springfield, Mass.
Stark Sound Engrg. Corp., P. O. 493, Fort Wayne 1, Ind.
Talking Devices Co., 4447 W. Irving Park Rd., Chicago, Ill.
Taybern Equipment Co., 120 Greenwich St., New York 6, N. Y.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Technical Devices Corp., Beaufort & Eagle Rock Aves., Roseland, N. J.
Technical Radio Co., 275 Ninth St., San Francisco, Calif.
Televiso Products, Inc., 6533 N. Olmsted Ave., Chicago, Ill.
Templetone Radio Mfg. Corp., New London, Conn.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York, N. Y.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
United States Television Mfg. Corp., 106 Seventh Ave., New York, N. Y.
Valco Mfg. Co., 4700 W. Walton St., Chicago 51, Ill.
Walsh Engineering Co., 34 DeHart Place, Elizabeth, N. J.

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ELECTRONIC and ALLIED PRODUCTS

Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill.
Waters Conley Co., 501 First St., N.W., Rochester, Minn.
Waugh Labs., Div. of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Webster Electric Co., 1900 Clark St., Racine, Wis.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Western Sound & Electric Labs, 3512 West St. Paul Ave., Milwaukee, Wis.
Westinghouse Electric Corp., East Pittsburgh, Pa.
White Research, 899 Boylston St., Boston, Mass.
Wilcox Electric Co., 1400 Chestnut Street, Kansas City, Mo.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.
Wurlitzer Mfg. Co., Rudolph, North Tonawanda, N. Y.

Analyzers

CIRCUIT ANALYZERS

Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Clough-Brengle Co., 5501 N. Broadway, Chicago 22, Ill.
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electrical Facilities, Inc., 4224 Holden St., Oakland 8, Calif.
Espey Mfg. Co. Inc., 35 West 46th St., New York 19, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Cal.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
H-W Mfg. Co., 3124 Larga Ave., Los Angeles, Cal.
Jackson Electrical Instrument Co., 18 S. Patterson Blvd., Dayton 1, Ohio
J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Madison Electrical Products Corp., Madison, N. J.
Philco Corp., Tioga & C Sts., Philadelphia, 34, Pa.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Radio City Products Co., 127 W. 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Readrite Meter Works, College Ave., Bluffton, Ohio
Roller-Smith, Bethlehem, Pa.
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sound Equipment Corp. of California, 3903 San Fernando Road, Glendale 4, Calif.
Supreme Instruments Corp., Greenwood, Miss.
Televiso Products, Inc., 6533 N. Olmsted Ave., Chicago, Ill.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Triumph Mfg. Co., 913 W. Van Buren St., Chicago 7, Ill.
Westinghouse Electric Corp., East Pittsburg, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

COLOR ANALYZERS

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Coleman Electric Co., 318 Madison St., Maywood, Ill.
Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.
General Electric Co., Schenectady 5, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y.
Pho-Tron Instrument Co., 5713 Euclid Ave., Cleveland, Ohio
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Saxl Instrument Co., 38-40 James St., East Providence 14, R. I.
Technical Products Co., 158 Madison Ave. at Third St., Memphis, Tenn.
White Research, 899 Boylston St., Boston, Mass.

HARMONIC ANALYZERS

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Cal.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.
Philharmonic Radio Corp., 528 East 72nd St., New York 21, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
White Research, 899 Boylston St., Boston, Mass.

NOISE ANALYZERS

Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Ferris Instrument Co., 110-112 Cornelia St., Boonton, N. J.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Measurements Corp., Boonton, N. J.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Sprague Electric Co., 189 Beaver St., North Adams, Mass.
Televiso Products, Inc., 6533 N. Olmsted Ave., Chicago, Ill.
Waugh Labs., Div. of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.

SURFACE ANALYZERS & COMPARATORS

Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Continental Machines, Inc., 1301 Washington Ave. S., Minneapolis 4, Minn.
General Electric Co., Schenectady 5, N. Y.
Physicists Research Co., 343 S. Main St., Ann Arbor, Mich.
Saxl Instrument Co., 38-40 James St., East Providence 14, R. I.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.

TRANSMISSION ANALYZERS

Cinema Engineering Co., 1508 W. Verdugo Ave., Burbank, Calif.
Daven Co., 191 Central Ave., Newark 4, N. J.

Anodes

CARBON ANODES

Becker Bros. Carbon Co., 3450 S. 52nd Ave., Cicero, Ill.
Dixon Crucible Co., Joseph, Monmouth St., Jersey City, N. J.
General Electric Co., Schenectady 5, N. Y.
Helwig Co., 2544 North 30th St., Milwaukee 10, Wisc.
National Carbon Co., Inc., 30 East 42nd St., New York 17, N. Y.
Ohio Carbon Co., 12508 Berea Rd., Cleveland, Ohio
Speer Carbon Co., St. Marys, Pa.
Stackpole Carbon Co., St. Marys, Pa.

METAL ANODES

American Brass Co., Waterbury 88, Conn.
Art Wire & Stamping Co., 227 High St., Newark 2, N. J.
Belmont Smelting & Refining Works, Inc., 330 Belmont Ave., Brooklyn 7, N. Y.
Bishop & Co. Platinum Works, J., 12 Channing Ave., Malvern, Pa.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Division Lead Co., 836 W. Kinzie St., Chicago 22, Ill.
DuPont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Fansteel Metallurgical Corp., 2200 Sheridan Rd., North Chicago, Ill.
General Electric Co., Schenectady 5, N. Y.
Goldsmith Bros. Smelting & Refining Co., 58 E. Washington St., Chicago, Ill.
Handy & Harman, 82 Fulton St., New York, N. Y.
Haydu Bros., Mt. Bethel Rd., Plainfield, N. J.
National Lead Co., 111 Broadway, New York 6, N. Y.
Radio Corp. of America, Tube Div., RCA, Harrison, N. J.
Revere Copper & Brass Inc., 230 Park Ave., New York 17, N. Y.
Rice's Sons, Inc., Bernard, 325 Fifth Ave., New York, N. Y.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Superior Tube Co., Norristown, Pa.
Swedish Iron & Steel Corp., 17 Battery Place, New York, N. Y.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Antenna Mounts

Shur-Antenna-Mount, Inc., Seacliffe, Long Island, N. Y.

Antennas

RECEIVING ANTENNAS

Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kans.
Airplane & Marine Instruments Inc., Clearfield, Pa.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway S., Mt. Vernon, N. Y.
Amy, Aceves & King, Inc., 11 W. 42nd St., New York 18, N. Y.
Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Andrew Co., 363 East 75th St., Chicago 19, Ill.
Bassett, Inc., Rex, 500 S.E. Second St., Ft. Lauderdale, Fla.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Brach Mfg. Corp., L. S., 55 Dickerson St., Newark, N. J.
Burton-Rogers Co., 857 Boylston St., Boston 16, Mass.
Cardy-Lundmark Co., 1801 West Byron St., Chicago 13, Ill.
Columbia Wire & Supply Co., 4106 N. Pulaski Road, Chicago 41, Ill.
Communications Co., Inc., 300 Greco Ave., Coral Gables 34, Fla.
Communications Equipment Corp., 134 West Colorado St., Pasadena 1, Calif.
Concord Radio Corp., 901 W. Jackson Blvd., Chicago, Ill.
Cornish Wire Co., 15 Park Row, New York, N. Y.
DeMornay-Budd, Inc., 475 Grand Concourse, New York, N. Y.
Du Mont Labs., Inc., Allen B., 2 Main Ave., Passaic, N. J.
Farnsworth Television & Radio Corp., 3702 Pontiac St., Fort Wayne, Ind.
Fisher Research Laboratory, 1961 University Ave., Palo Alto, Calif.
Fishwick Radio Co., 430 Colorado Bldg., Washington, D. C.
Fleron & Son, Inc., M. M., 113 N. Broad St., Trenton, N. J.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago 51, Ill.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
Harco Steel Construction Co., 1180 E. Broad St., Elizabeth 4, N. J.

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Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Heath Co., Benton Harbor, Mich.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
J. F. D. Mfg. Co., 4111 Fort Hamilton Pkwy., Brooklyn, N. Y.
Jefferson-Travis Radio Mfg. Corp., 245 East 23rd St., New York 10, N. Y.
Johnson Co., E. F., Waseca, Minn.
Kings Electronics Co., 372 Classon Ave., Brooklyn 5, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lavoie Laboratories, Morganville, N. J.
Lear, Inc., Piqua, Ohio.
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton, N. J.
Link, Fred M., 125 W. 17th St., New York, N. Y.
Magnavox Co., The, 2131 Bueter Road, Fort Wayne 4, Ind.
Mec-Rad Div., Black Industries, 1440 E. 222nd St., Cleveland 17, Ohio (H. F. Components)
National Electronic Mfg. Corp., 22-78 Steinway St., Long Island City 5, N. Y.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
Philco Corp., Tioga & C Sts., Philadelphia 34, Pa.
Philson Mfg. Co., Inc., 156 Chambers St., New York, N. Y.
Plymold Corp., Lawrence, Mass.
Premax Products Div., Chisholm-Ryder Co., College & Highland Aves., Niagara Falls 2, N. Y.
Radex Corp. of America, 1322 Elston Ave., Chicago, Ill.
Radiart Corp., 3571 W. 62nd St., Cleveland 2, Ohio
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Schuttig & Co., 9th & Kearney Sts., N. E., Washington 17, D. C.
Skydyne Inc., River Road, Port Jervis, N. Y.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Snyder Mfg. Co., 22nd & Ontario Sts., Philadelphia 40, Pa.
Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
Superior Tube Co., Norristown, Pa.
Technical Appliance Corp., 516 W. 34th St., New York 1, N. Y.
Telephonics Corp., 350 West 31st St., New York 1, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Trebor Radio Co., Pasadena, Calif.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
United States Television Mfg. Corp., 106 Seventh Ave., New York, N. Y.
Vendo Co., 1907 Grand Ave., Kansas City, 8, Mo.
Ward Products Corp., 1523 E. 45th St., Cleveland 3, Ohio
Whisk Laboratories, 87 Maiden Lane, New York 7, N. Y.
Winters & Crampton Corp., 150 Wilson Ave., Grandville, Mich.
Workshop Associates, 66 Needham St., Newton Highlands, Gardner, Mass.

TRANSMITTING ANTENNAS

Aero Communications, Inc., 231 Main St., Hempstead, Long Island, N. Y.
Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kans.
Airplane & Marine Instruments, Inc., Clearfield, Pa.
American Bridge Co., Frick Bldg., Pittsburgh, Pa.
Andrew Co., 363 E. 75th St., Chicago 19, Ill.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bassett, Inc., Rex, 500 S. E. Second St., Ft. Lauderdale, Fla.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Blaw-Knox Co., Farmers Bank Bldg., Pittsburgh, Pa.
Brach Mfg. Corp., 55 Dickerson St., Newark, N. J.
Collins Radio Co., 855-35th St., N.E., Cedar Rapids, Iowa
Communication Products Co., Inc., 346 Bergen Ave., Jersey City 5, N. J.
Communications Co. Inc., 300 Greco Ave., Coral Gables 34, Fla.
Communications Equipment Corp., 134 West Colorado St., Pasadena 1, Calif.
DeMornay-Budd, Inc., 475 Grand Concourse, New York, N. Y.
Erco Radio Laboratories, Inc., Fenimore Avenue, Hempstead, N. Y.
Farnsworth Television & Radio Corp., 3702 Pontiac St., Fort Wayne, Ind.
Fisher Research Laboratory, 1961 University Ave., Palo Alto, Calif.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
Grady Instrument Co., 11 Bailey Ave., Watertown 72, Mass.
Harco Steel Construction Co., Inc., 1180 E. Broad St., Elizabeth 4, N. J.
Hoke Vertical Radiator Co., 135 S. Market St., Petersburg, Va.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Isolantite, Inc., 343 Cortlandt St., Belleville 9, N. J.
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, L. I., N. Y.
Jefferson-Travis Radio Mfg. Corp., 245 East 23rd St., New York 10, N. Y.
Johnson Co., E. F., Waseca, Minn.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Kings Electronics Co., 372 Classon Ave., Brooklyn 5, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lavoie Laboratories, Morganville, N. J.
Lear, Inc., Piqua, Ohio
Lehigh Structural Steel Co., 17 Battery Pl., New York 4, N. Y.
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton, N. J.
Lingo & Son, John E., 28th St. & Buren Ave., Camden, N. J.
Link, Fred M., 125 W. 17th St., New York, N. Y.
Mec-Rad Div., Black Industries, 1440 E. 222nd St., Cleveland 17, Ohio (H. F. Components)
National Electronic Mfg. Corp., 22-78 Steinway St., Long Island City, N. Y.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
Plymold Corp., Lawrence, Mass.
Premax Products Div., Chisholm Ryder Co., College & Highland Ave., Niagara Falls 2, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Engineering Labs., Inc., 35-54 36th St., Long Island City, N. Y.
Radio Receptor Co., 251 W. 19th St., New York 11, N. Y.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Schuttig & Co., 9th & Kearney Sts., N. E., Washington 17, D. C.
Skydyne Inc., River Road, Port Jervis, N. Y.
Snyder Mfg. Co., 22nd & Ontario Sts., Philadelphia 40, Pa.
Superior Tube Co., Norristown, Pa.
Technical Radio Co., 275 Ninth St., San Francisco, Calif.
Truscon Steel Co., Youngstown, Ohio
United States Television Mfg. Corp., 106 Seventh Ave., New York, N. Y.
Vendo Co., 1907 Grand Ave., Kansas City 8, Mo.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wincharger Corp., 7th & Division Sts., Sioux City, Iowa
Winters & Crampton Corp., 150 Wilson Ave., Grandville, Michigan
Workshop Associates, 66 Needham St., Newton Highlands, Gardner, Mass.

Attenuators

see Controls

Ballasts

see Tubes

Batteries

DRY BATTERIES

Acme Battery Corp., 59 Pearl St., Brooklyn, N. Y.
Bond Electric Corp., Div. of Olin Industries, Inc., New Haven 4, Conn.
Bright Star Battery Co., 200 Crooks Ave., Clifton, N. J.
Burgess Battery Co., Foot of Exchange St., Freeport, Ill.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
General Dry Batteries, Inc., 13000 Athens Ave., Cleveland, Ohio
Marathon Battery Co., Wausau, Wisc.
National Carbon Co., Inc., 30 East 42nd St., New York 17, N. Y.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Olin Industries, East Alton, Ill.
Philco Corp., (Battery Division), Philadelphia 34, Pa.
Radio Corp. of America, Tube Div., RCA., Harrison, N. J.
Ray-O-Vac Co., Madison, Wis.
Southern Battery Co., Appomattox, Va.
Transelectric Mfg. Co., Oxford, Pa.
United States Electric Mfg. Corp., 223 W. 14th St., New York, N. Y.
Western Cable Battery Co., Inc., 395 Sibley St., St. Paul, Minn.

STORAGE BATTERIES

American Battery Co., 17 E. Jefferson St., Chicago, Ill.
Am-plus Storage Battery Co., 425 W. Superior St., Chicago, Ill.
Auto-Lite Battery Corp., P. O. Box 931, Toledo, Ohio
Automatic Electrical Devices Co., 324 E. Third St., Cincinnati 2, Ohio
Bowers Battery & Spark Plug Co., Reading, Pa.
Centralab Div. of Globe Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Edison Storage Battery Div., Thomas A. Edison, Inc., Main St. at Lakeside Ave., West Orange, N. J.
Electric Auto-Lite Co., Toledo 1, Ohio
Electric Storage Battery Co., Allegheny Ave. & 19th St., Philadelphia 32, Pa.
General Lead Batteries Co., 196 West Railway Ave., Paterson, N. J.
General Storage Battery Co., 2005 Locust St., St. Louis, Mo.
Gould Storage Battery Corp., 35 Neoga St., Depew, N. Y.
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.
K. W. Battery Co., 3705 N. Lincoln Ave., Chicago 13, Ill.
Koehler Mfg. Co., Marlboro, Mass.
Monark Battery Co., Inc., 1240 N. Homan Ave., Chicago, Ill.
National Battery Co., First National Bank Bldg., St. Paul, Minn.
Perrine Quality Products Corp., 55 Rumford Ave., Waltham 54, Mass.
Philco Corp., (Storage Battery Division), Philadelphia 34, Pa.
Prest-O-Lite Battery Co., Inc., 4500 W. 16th St., Box 1655, Indianapolis, Ind.
Solar Corp., 944 W. Bruce St., Milwaukee 4, Wis.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Universal Battery Co., 3410 S. La Salle St., Chicago, Ill.
Western Cable Battery Co., Inc., 395 Sibley St., St. Paul, Minn.
Willard Storage Battery Co., 246 E. 131st St., Cleveland 1, Ohio

Bearings, Miniature

Ace Mfg. Corp., 1255 E. Erie Ave., Philadelphia, Pa.
Bird & Co., Waltham, Mass.
Bound Brook Oil-less Bearing Co., Bound Brook, N. J.
General Plate Div., Metals & Controls Corp., 34 Forest St., Attleboro, Mass.
Graphite Metallizing Corp., 1055 Nepperham Ave., Yonkers 3, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Miniature Precision Bearings, Keene, N. H.
Moraine Products Div., General Motors Corp., Dayton, Ohio
United States Graphite Co., 1621 Holland Ave., Saginaw, Mich.

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ELECTRONIC and ALLIED PRODUCTS

Bellows

Chicago Metal Hose Corp., 1309 S. Third Ave., Maywood, Ill.
Clifford Mfg. Co., 564 E. First, Boston, Mass.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Fulton Sylphon Co., Knoxville, Tenn.
Giannini & Co., Inc., G. M., 161 E. California St., Pasadena, Calif.

Blanks, Recording

see Discs

Blowers, Small

Chelsea Products, Inc., 1206 Grove St., Irvington, N. J.
Delco Appliance Division, General Motors Corp., Rochester, N. Y.
Dynamic Air Engineering, Inc., 1619 So. Alameda St., Los Angeles 11, Calif.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
Eastern Engineering Co., 45 Fox St., New Haven 13, Conn.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Haydu Bros., Mt. Bethel Rd., Plainfield, N. J.
Heinze Electric Corp., Lowell, Mass.
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.
Ilg Electric Ventilating Co., 2850 N. Crawford Ave., Chicago 41, Ill.
L-R Manufacturing Co., 65 New Litchfield St., Torrington, Conn.
Leiman Bros., 203 Christie St., Newark 5, N. J.
Redmond Co. Inc., Monroe St., Owosso, Mich.
Small Motors, Inc., 1322 Elston Ave., Chicago, Ill.
Smith Mfg. Co., F. A., P. O. Box 509, Rochester 2, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Blue, and Black-White Printing Machinery

Bruning Co. Inc., Charles, 4700 Montrose Ave., Chicago 41, Ill.
Ozalid Products Div., General Aniline & Film Corp., 770 Ansco Rd., Johnson City, N. Y.
Paragon Revolute Corp., 97 South Ave., Rochester 4, N. Y.
Pease Company, C. F., 2601 W. Irving Park Rd., Chicago 18, Ill.
Peck & Harvey, 4327 Addison St., Chicago, Ill.
Photo Reproducing Equipment Co., Chatham, N. J.
Shaw Blue Print Machine Co., Inc., 12 East Park St., Newark 2, N. J.
Wickes Brothers, 515 N. Washington Ave., Saginaw, Mich.

Bolts, Expansion

Ackerman-Johnson Co., 625 W. Jackson Blvd., Chicago, Ill.
American Expansion Bolt & Mfg. Co., 909 N. Spaulding St., Chicago, Ill.
Anchor Products Co., 175 Fifth Ave., New York, N. Y.
Apex Bolt Products Co., 1301 Carroll Ave., Chicago, Ill.
Arro Expansion Bolt Co., 740 W. Center St., Marion, Ohio
Bayonne Bolt Corp., 32 W. Second St., Bayonne, N. J.
Bethlehem Steel Co., 701 E. Third St., Bethlehem, Pa.
Chicago Expansion Bolt Co., 2240 W. Ogden Ave., Chicago 12, Ill.
Church Expansion Bolt Co., Isaac, 1 Fourth St., East Norwalk, Conn.
Croessant Machine Works, 39 Moss St., Reading, Pa.
Diamond Expansion Bolt Co., Garwood, N. J.
Green, Inc., R. H., Dayton 1, Ohio
Line Material Co., 800 N. Eighth St., Milwaukee, Wisc.
National Lead Co., 111 Broadway, New York 6, N. Y.
Ohio Brass Co., Mansfield, Ohio
Oliver Iron & Steel Corp., S. Tenth & Muriel Sts., Pittsburgh 3, Pa.
Paine Co., 2961 Carroll Ave., Chicago 12, Ill.
Palatine Industrial Co., 111 Fifth Ave., New York 3, N. Y.
Phillips Drill Co., 1537 Cortland St., Chicago, Ill.
Rawlplug Co., 98 Lafayette St., New York, N. Y.
Seyler Mfg. Co., Butler Plank Rd., Pittsburgh, Pa.
Star Expansion Bolt Co., 147 Cedar St., New York 6, N. Y.
Steel City Electric Co., 1207 Columbus Ave., Pittsburgh 12, Pa.
Sterling Bolt Co., 209 W. Jackson Blvd., Chicago 6, Ill.
Steward & Romaine Mfg. Co., 124 N. Sixth St., Philadelphia, Pa.
United Screw & Bolt Corp., 2513 W. Cullerton St., Chicago, Ill.
U. S. Expansion Bolt Co., York, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Bombarders

Ecco High Frequency Electric Corp., 7020 Hudson Blvd., North Bergen, N. J.
Lepel High Frequency Laboratories, 39 West 60th St., New York, N. Y.
Radio Corp. of America, Tube Div., RCA., Harrison, N. J.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 119 Monroe St., Garfield, N. J.
Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y.

Breakers

CIRCUIT BREAKERS (for electronic applications)

Allis Chalmers Mfg. Co., Milwaukee 1, Wisc.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Federal Electric Products Co., Inc., 50 Paris St., Newark, N. J.
General Electric Co., Schenectady 5, N. Y.
Heinemann Circuit Breaker Co., 97 Plum St., Trenton 2, N. J.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Littelfuse, Inc., 4755 Ravenswood Ave., Chicago, Ill.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Roller-Smith, Bethlehem, Pa.
Smith Mfg. Co., F. A., P. O. Box 509, Rochester 2, N. Y.
Spencer Thermostat Co., Attleboro, Mass.
Square D Co., 6060 Rivard St., Detroit 11, Mich.
Trumbull Electric Mfg. Co., Plainville, Conn.
Westinghouse Electric Corp., East Pittsburgh, Pa.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

Bridges

ELECTRICAL MEASUREMENT BRIDGES

see Analyzers
also Testers

Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Baldwin Locomotive Works, Eddystone, Pa.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Central Scientific Co., 1700 Irving Park Blvd., Chicago 13, Ill.
Clough-Brengle Co., 5501 N. Broadway, Chicago 22, Ill.
Communication Measurements Laboratory, 120 Greenwich St., New York, N. Y.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Cornell-Dubilier Electric Corp., 1000 Hamilton Blvd., South Plainfield, N. J.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electronic Supply Co., 207 Main St., Worcester, Mass.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
Foxboro Co., Foxboro, Mass.
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gray Instrument Co., 64½ W. Johnston St., Philadelphia, Pa.
Grenby Mfg. Co., Plainville, Conn.
H-W Mfg. Co., 3124 Larga Ave., Los Angeles, Calif.
Hatry & Young, 203 Ann St., Hartford, Conn.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia, Pa.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Industrial Instruments, Inc., 156 Culver Ave., Jersey City 5, N. J.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Marion Electrical Instrument Co., Manchester, N. H.
Portable Products Corp., C. J., Tagliabue Div., 550 Park Ave., Brooklyn 5, N. Y.
Radio City Products Co., Inc., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Richardson-Allen Corp., 15 West 20th St., New York, N. Y.
Roller-Smith, Bethlehem, Pa.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Standard Instruments Corp., 568 Prospect Ave., New York 55, N. Y.
Tech Laboratories, 7 Lincoln St., Jersey City, N. J.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Pa.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Waugh Labs., Div. of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
White Research, 899 Boylston St., Boston, Mass.
Winslow Co., 9 Liberty St., Newark 5, N. J.

Broadcast Monitors

see Monitors, Broadcast

Brushes, Carbon & Graphite

Becker Brothers Carbon Co., 3450 S. 52nd Ave., Chicago, Ill.
Calebaugh Self-Lubricating Carbon Co., Inc., 2245 E. Ontario St., Philadelphia, Pa.
Carbon Engineering Corp., Slinger, Wis.
Carbone Corp., Myrtle Ave., Boonton, N. J.
Dixon Crucible Co., Joseph, Monmouth St., Jersey City, N. J.
Electro-Nite Carbon Co., 1133 E. Columbia Ave., Philadelphia, Pa.
General Electric Co., Schenectady 5, N. Y.
Graphite Metallizing Corp., 1055 Nepperhan Ave., Yonkers 3, N. Y.

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Helwig Co., 2544 North 30th St., Milwaukee 10, Wisc.
Henrite Products Corp., Ironton, Ohio
Keystone Carbon Co., Inc., 1935 State St., St. Marys, Pa.
LeValley-Vitae Carbon Brush Co., Rombout Ave., Beacon, N. Y.
Morganite Brush Co., 33-02 48th Ave., Long Island City, N. Y.
National Carbon Co., 30 East 42nd St., New York 17, N. Y.
Ohio Carbon Co., 12508 Berea Rd., Cleveland, Ohio
Pittsburgh Carbon Brush Co., 811 Fulton St., Pittsburgh 12, Pa.
Pure Carbon Co., St. Marys, Pa.
St. Mary's Carbon Co., St. Marys, Pa.
Seager Carbon Co., 68 Barclay St., New York 7, N. Y.
Snarr & Co., Geo. W., 110 S. Ninth St., St. Louis 2, Mo.
Southern Carbon Brush Co., P. O. Box 2021, 109 N. 11th St., Birmingham 1, Ala.
Speer Carbon Co., Lincoln Ave., St. Marys, Pa.
Stackpole Carbon Co., St. Marys, Pa.
Superior Carbon Products, Inc., 9112 George Ave., Cleveland, Ohio.
Tungsten Contact Mfg. Co., North Bergen, N. J.
United States Graphite Co., 1621 Holland Ave., Saginaw, Mich.

Cabinets

CABINETS, CHASSIS AND PANELS

Altec Lansing Corp., 1680 N. Vine St., Los Angeles 28, Calif.
Aluminum Goods Mfg. Co., Manitowoc, Wis.
American Communications Corp., 306 Broadway, New York, N. Y.
American Insulator Corp., New Freedom, Pa.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway S., Mt. Vernon, N. Y.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Austin Co., O., 42 Greene St., New York, N. Y.
Baer Co., N. S., 9 Montgomery St., Hillside, N. J.
Bakelite Corp., 30 East 42nd St., New York 17, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Caswell-Runyon Co., Huntington, Ind.
Churchill Cabinet Co., 2119 Churchill Ave., Chicago 22, Ill.
Cole Steel Equipment Co., 349 Broadway, New York 13, N. Y.
Collins Radio Co., 855-35th St. N. E., Cedar Rapids, Iowa.
Columbia Metal Box Co., 260 E. 143rd St., New York, N. Y.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Corry-Jamestown Mfg. Corp., Corry, Pa.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
Dahlstrom Metallic Door Co., Buffalo St., Jamestown, N. Y.
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Edwards, Inc., T. J., 121 Beach St., Boston 5, Mass.
Electric Auto-Lite Co., Toledo 1, Ohio
Electrical Insulation Co., Inc., 12 Vestry St., New York, N. Y.
Electronic Supply Co., 207 Main St., Worcester, Mass.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Erie Art Metal Co., 1602 East 18th St., Erie, Pa.
Erie Can Co., 816 W. Erie St., Chicago, 22, Ill.
Etched Products Corp., 39-01 Queens Blvd., Long Island City, N. Y.
Falstrom Co., 7 Falstrom Court, Passaic, N. J.
Federal Electric Products Co., Inc., 50 Paris St., Newark, N. J.
Franklin Fibre-Lamitex Corp., 12th & French St., Wilmington, Del.
Garod Radio Corp., 70 Washington St., Brooklyn, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Schenectady 5, N. Y.
Goat Metal Stampings Inc., 314 Dean St., Brooklyn, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Grammes & Sons, Inc., L. F., 389 Union St., Allentown 2, Pa.
Hadley Co., Robert M., 711 E. 61st St., Los Angeles, Calif.
Hawley Products Co., St. Charles, Ill.
Hoffman Radio Corp., 3430 South Hill St., Los Angeles 7, Calif.
Hopp Press, Inc., 460 West 34th St., New York, N. Y.
Hudson American Corp., 25 West 43rd St., New York, N. Y.
Industrial Sound Products Co., 3597 Mission St., San Francisco, Calif.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Jefferson Travis Radio Mfg. Corp., 245 East 23rd St., New York 10, N. Y.
Johnson Co., E. F., Waseca, Minn.
Karp Metal Products Co., 129 Thirtieth St., Brooklyn, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lewyt Corp., 60 Broadway, Brooklyn, N. Y.
Lindsay & Lindsay, 222 W. Adams St., Chicago 6, Ill.
Market Forge Co., Everett, Mass.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Metallic Arts Co., 243 Broadway, Cambridge, Mass.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., 61 Sherman St., Malden 48, Mass.
National Vulcanized Fibre Co., Maryland Ave., Wilmington, Del.
New England Etching & Plating Co., 25 Spring St., Holyoke, Mass.
Olesen Illuminating Co., Ltd., Otto K., 1560 Vine St., Hollywood 28, Calif.
Olympic Tool & Mfg. Co., 37 Chambers St., New York 7, N. Y.
Par Metal Products Corp., 32-62 49th St., Long Island City, N. Y.
Penn Fibre & Specialty Co., 2030 E. Westmoreland St., Philadelphia 34, Pa.
Plastic Fabricators Co., 440 Sansome St., San Francisco 11, Calif.
Plastic Manufacturers, Inc., Stamford, Conn.
Porter Metal Products, 121 Ingraham St., Brooklyn 6, N. Y.
Premier Metal Etching Co., 21-03 44th Ave., Long Island City, N. Y.
Radiad Service, 720 West Schubert Ave., Chicago 14, Ill.
Remler Co., 2101 Bryant St., San Francisco 10, Calif.
Richardson Co., Melrose Park, Ill.
Santay Corporation, 351 North Crawford, Chicago 24, Ill.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Screenmakers, 64 Fulton St., New York, 1, N. Y.
Sherron Metallic Corp., 1201 Flushing Ave., Brooklyn 6, N. Y.
Signal Engineering & Mfg. Co., 154 West 14th St., New York, N. Y.
Silk Screen Supplies, Inc., 33 Lafayette Ave., Brooklyn, N. Y.
Simpson Mfg. Co., Mark, 188 West Fourth St., New York, N. Y.
Skydyne Inc., River Road, Port Jervis, New York
Sonora Radio & Television Corp., 2626 W. Washington St., Chicago 28, Ill.
Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N. Y.
Stamford Metal Specialty Co., 428 Broadway, New York 13, N. Y.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Standard Products Co., 505 Boulevard Bldg., Detroit 2, Mich.
Stokes Rubber Co., Jos., Taylor & Webster Sts., Trenton, N. J.
Syracuse Ornamental Co., 581 So. Clinton St., Syracuse, N. Y.
Templetone Radio Mfg. Corp., New London, Conn.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
Tork Clock Co., 1 Grove St., Mt. Vernon, N. Y.
Trebor Radio Co., Pasadena, Calif.
Tri-United Plastics Corp., 390 Nye Ave., Irvington, N. J.
Union Aircraft Products Corp., 380 Second Ave., New York, N. Y.
Victory Manufacturing Co., 1722 W. Arcade Pl., Chicago 12, Ill.
Wallace Mfg. Co., Wm. T., Chili & Madison Aves., Peru, Indiana
Waters Conley Co., 501 First St., N. W., Rochester, Minn.
Watterson Radio Mfg. Co., P. O. Box 54, Dallas 1, Texas
Wells-Gardner & Co., 2701 N. Kildare Ave., Chicago, Ill.
Wilcox Electric Co., 1400 Chestnut St., Kansas City, Mo.
Wilcox Gay Corp., Charlotte, Michigan
Willor Mfg. Co., 794 East 140th St., New York 54, N. Y.
Winters & Crampton Corp., 150 Wilson Ave., Grandville, Michigan
Wurlitzer Mfg. Co., Rudolph, North Tonawanda, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

Cable

see also Wire

COAXIAL CABLE

Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Andrew Co., 363 East 75th St., Chicago 19 Ill.
Belden Mfg. Co., 4647 W. Van Buren St., Chicago 44, Ill.
Boston Insulated Wire & Cable Co., 61 Bay St. (Dorchester), Boston, Mass.
Brach Mfg. Corp., L. S., 55 Dickerson St., Newark, N. J.
Columbia Electronics, Inc., 185 East 122nd St., New York 35, N. Y.
Communication Products Co., Inc., 34 Bergen Ave., Jersey City 5, N. J.
Doolittle Radio, Inc., 7421 S. Loomi Blvd., Chicago, Ill.
Eby, Inc., Hugh H., 18 W. Chelton Ave Philadelphia 13, Pa.
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Cable Corp., 420 Lexington Ave., New York, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Insulated Wire Corp., 53 Park Pl, New York, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Isolantite, Inc., 343 Cortlandt St., Belleville 9, N. J.
Johnson Co., E. F., Waseca, Minn.
Link, Fred M., 125 W. 17th St., New York, N. Y.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Okonite Co., Canal St., Passaic, N. J.
Precision Tube Co., 3828 Terrace St., Philadelphia 28, Pa.
Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y. (test equipment)
Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Uniform Tubes, Shurs Lane & Lauriston St., Roxborough, Philadelphia, Pa.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Whitney-Blake Co., Dixwell Ave., New Haven, Conn.
Whittaker-Cable Corp., North Kansas City, Mo.
Wood Electric Co., Inc., C. D., 826 Broadway, New York, N. Y.

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ELECTRONIC and ALLIED PRODUCTS

Capacitors

FIXED CAPACITORS

Aerovox Corp., 740 Belleville Ave., New Bedford, Mass. (Electrolytic, Mica, Oil, Paper)
Aircraft-Marine Products, Inc., 1523 N. Fourth St., Harrisburg, Pa.
American Condenser Co., 4410 Ravenswood Ave., Chicago, Ill. (Electrolytic, Paper)
Atlas Condenser Products Co., 548 Westchester Ave., Bronx, N. Y. (Electrolytic, Paper)
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill. (Paper)
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa. (Air, Oil)
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio (Air)
Capacitron Co., 849 No. Kedzie Ave., Chicago 51, Ill.
Cardwell Mfg. Corp., Allen D., 81 Prospect St., Brooklyn, N. Y.
Centralab Div., Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis. (Ceramic, Mica)
Condenser Corp. of America, 1000 Hamilton Blvd., South Plainfield, N. J. (Electrolytic, Mica, Oil, Paper)
Condenser Products Co., 1375 N. Branch St., Chicago, Ill. (Electrolytic, Oil, Paper)
Continental Carbon, Inc., 13900 Lorain Ave., Cleveland, Ohio (Paper)
Cornell-Dubilier Electric Corp., 1000 Hamilton Blvd., South Plainfield, N. J. (Electrolytic, Mica, Oil-filled, Motor-starting, Paper, Air, X-Ray, etc.)
Cosmic Radio Corp., 699 E. 135th St., New York, N. Y.
Crowley & Co., Inc., Henry L., 1 Central Ave., West Orange, N. J.
Deutschmann Corp., Tobe, Canton, Mass. (Paper, Mica, Electrolytic, Oil, Ceramic, Air, etc.)
Dumont Electric Co., 34 Hubert St., New York, N. Y. (Electrolytic, Mica, Oil, Paper)
Ecco High Frequency Electric Corp., 7020 Hudson Blvd., North Bergen, N. J.
Eitel-McCullough, Inc., San Bruno, Calif. (Vacuum)
Electrical Reactance Corp., Franklinville, N. Y.
Electro-Motive Mfg. Co., S. Park & John Sts., Willimantic, Conn. (Mica)
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Erie Resistor Corp., 644 W. 12th St., Erie Pa. (Ceramic)
Fast & Co., John E., 3101 N. Pulaski Rd., Chicago 41, Ill.
General Electric Co., Schenectady 5, N. Y. (Air Trimmer, Oil, Paper, Vacuum, Radio-Frequency blocking & by-pass, High-Frequency Power or Plate)
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass. (Air, Mica, Paper)
Girard-Hopkins, 1000 40th Ave., Oakland 1, Calif. (Oil, Paper)
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb. (Oil, Paper)
H. R. S. Products, 5707 W. Lake St., Chicago, Ill.
Illinois Condenser Co., 1160 N. Howe St., Chicago, Ill. (Electrolytic, Oil, Paper)
Industrial Condenser Corp., 3243 North California Ave., Chicago 18, Ill. (Ceramic, Electrolytic, Mica, Oil, Paper)
Industrial & Commercial Electronics, Belmont, Calif.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Calif. (Vacuum)
Johnson Co., E. F., Waseca, Minn. (Air, Oil)
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill. (Oil & Wax filled, Paper, Oil, Impregnated & Wax Impregnated)
Lapp Insulator Co., 31 Gilbert St., Le Roy, N. Y. (Ceramic)
Magnavox Co., 2131 Bueter Rd., Fort Wayne 4, Ind. (Electrolytic)
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind. (Electrolytic, Paper)
Micamold Radio Corp., 1087 Flushing Ave., Brooklyn 6, N. Y. (Ceramic, Electrolytic, Mica, Oil, Paper)
Muter Co., 1255 S. Michigan Ave., Chicago, Ill. (Ceramic)
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Noma Electric Corp., 55 West 13th St., New York 11, N. Y. (Mica)
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Polymet Condenser Co., 699 East 135th St., New York, N. Y.
Potter Co., 1950 Sheridan Rd., North Chicago, Ill. (Oil, Paper)
Radio Corp. of America, RCA Victor Div., Camden, N. J. (Mica, Oil, Paper)
Rothenstein, Albert, 135 Liberty St., New York, N. Y.
Sangamo Electric Co., Springfield, Ill. (Mica, Ceramic, Paper)
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J.
Sickles Co., F. W., 165 Front St., Chicopee, Mass. (Mica, Silver, Mica)
Solar Mfg. Corp., 285 Madison Ave., New York 17, N. Y. (Ceramic, Electrolytic, Mica, Oil, Paper)
Sprague Electric Co., 189 Beaver St., North Adams, Mass. (Electrolytic, Mica, Oil, Paper)
Stackpole Carbon Co., St. Marys, Pa.
Teleradio Engineering Corp., 99 Wall St., New York 5, N. Y. (Mica)
Tungsten Contact Mfg. Co., North Bergen, N. J.
Western Electric Co. Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa. (Oil, Paper)
Winters & Crampton Corp., 150 Wilson Ave., Grandville, Michigan

COMPRESSED GAS CAPACITORS

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Johnson Co., E. F., Waseca, Minn.
Lapp Insulator Co., 31 Gilbert St., Le Roy, N. Y.

VARIABLE RECEIVER TUNING CAPACITORS

American Steel Package Co., Squire Ave., Defiance, Ohio
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Cardwell Mfg. Corp., Allen D., 81 Prospect St., Brooklyn, N. Y.
Federal Mfg. & Engrg. Corp., 199-217 Steuben St., Brooklyn 5, N. Y.
Foote Pierson & Co. Inc., 75 Hudson St., Newark 4, N. J.
General Electric Co., Schenectady 5, N. Y.
General Instrument Corp., 829 Newark Ave., Elizabeth 3, N. J.
Halstead Traffic Communications Corp., 155 East 44th St., New York, N. Y.
Hammarlund Mfg. Co., Inc., 460 W. 34 St., New York 1, N. Y.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles 7, Calif.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co. E. F., Waseca, Minn.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., Inc., 61 Sherman St., Malden, 48, Mass.
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Radio Condenser Co., Camden, N. J.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.
Winters & Crampton Corp., 150 Wilson Ave., Grandville, Mich.

VARIABLE TRANSMITTER TUNING CAPACITORS

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Cardwell Mfg. Corp., Allen D., 81 Prospect St., Brooklyn, N. Y.
Collins Radio Co., 855-35th St., N. E., Cedar Rapids, Iowa
Federal Manufacturing & Engrg. Corp., 199-217 Steuben St., Brooklyn 5, N. Y.
Foote Pierson & Co. Inc., 75 Hudson St., Newark 4, N. J.
General Electric Co., Schenectady 5, N. Y.
General Instrument Corp., 829 Newark Ave., Elizabeth 3, N. J.
Hammarlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Calif.
Johnson Co., E. F., Waseca, Minn.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Lapp Insulator Co., 31 Gilbert St., LeRoy, N. Y.
Litton Engineering Labs., P. O. Box 749, Redwood City, Calif.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.
Wilcox Electric Co., 1400 Chestnut St., Kansas City, Mo.
Winters & Crampton Corp., 150 Wilson Ave., Grandville, Mich.

VARIABLE TRIMMER CAPACITORS

American Steel Package Co., Squire Ave., Defiance, Ohio
Automatic Mfg. Co., 900 Passaic Ave., East Newark, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Cardwell Mfg. Corp., Allen D., 81 Prospect St., Brooklyn, N. Y.
Centralab Div., Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.
Comar Electric Co., 3150 N. Washtenaw Ave., Chicago 28, Ill.
D X Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Electro Motive Mfg. Co., Willimantic, Conn.
Erie Resistor Corp., 644 W. 12th St., Erie, Pa.
Foote Pierson & Co. Inc., 75 Hudson St., Newark 4, N. J.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Guthman, Inc., E. I., 15 S. Throop St., Chicago, Ill.
Hammarlund Mfg. Co., Inc., 460 W. 34 St., New York 1, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Muter Co., 1255 S. Michigan Ave., Chicago, Ill.
National Co., Inc., 61 Sherman St., Malden, 48, Mass.
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Sickles Co., F. W., 165 Front St., Chicopee, Mass.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.
Teleradio Engineering Corp., 99 Wall St., New York 5, N. Y.

Cells

PHOTO-ELECTRIC CELLS

see Tubes (Phototubes & Cells)

Cements

RADIO CEMENTS

Alden Products Co., 117 North Main St., Brockton 64, Mass.

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Ambroid Co., 305 Franklin St., Boston 10, Mass.
American Products Mfg. Co., 8127 Oleander St., New Orleans, La.
Bakelite Corp., 30 E. 42nd St., New York 17, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Crowley & Co., Inc., Henry L., 1 Central Ave., West Orange, N. J.
D X Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Haynes Laboratories, Inc., C. W., 61 Chandler St., Springfield, Mass.
Howe & French, Inc., 99 Broad St., Boston 10, Mass.
Linicky & Co., Leslie L., 29 E. Madison St., Chicago, Ill.
Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.
Paisley Products, Inc., 1770 Canalport Ave., Chicago 16, Ill.
Plax Corp., 133 Walnut St., Hartford 5, Conn.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Cal.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Westinghouse Electric Corp., East Pittsburg, Pa.
Zapon Div. Atlas Powder Co., Ludlow St., Stamford, Conn.
Zophar Mills, Inc., 112 26th St., Brooklyn 32, N. Y.

Ceramics

see Insulation

Chambers, Test

HUMIDITY, PRESSURE, TEMPERATURE

American Instrument Co., 8030 Georgia Ave., Silver Springs, Md.
Bowser, Inc., Mobile Refrigeration Div., 38-32 54th St., Woodside, Long Island, N. Y.
Deepfreeze Division, Motor Products Corp., 2301 Davis St., N. Chicago, Ill.
Distillation Products, Inc., 755 Ridge Rd. W., Rochester, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Industrial Filter & Pump Mfg. Co., 1621-25 W. Carroll Ave., Chicago, Ill.
Kold-Hold Mfg. Co., 446 North Grand Ave., Lansing, Mich.
Northern Laboratories Ltd., 3-01—27th Ave., Long Island City, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Revco Inc., Deerfield, Mich.
Sparkes Mfg. Co., Ltd., 318 Jefferson St., Newark, N. J.
Technical Products Co., 158 Madison at Third St., Memphis, Tenn.
Tenney Engineering, Inc., 24-28 Avenue B, Newark, N. J.
Thwing Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Pa.
Waugh Labs., Div. of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Young Bros. Co., 6500 Mack Ave., Detroit, Mich.

Changers

AUTOMATIC RECORD CHANGERS

Admiral Corp., 3800 W. Cortland St., Chicago 47, Ill.
Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Chicago Sound Systems Co., 2124 S. Michigan Avenue, Chicago, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven 11, Conn.
Farnsworth Television & Radio Corp., 3702 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 W. Augusta Blvd., Chicago 51, Ill.
Garod Radio Corp., 70 Washington St., Brooklyn, N. Y.
Garrard Sales Corp., 401 Broadway, New York 13, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Industries Co., Taylor & Olive Sts., Elyria, Ohio
General Instrument Corp., 829 Newark Ave., Elizabeth 3, N. J.
International Detrola Corp., Beard at Chatfield, Detroit, Mich.
Magnavox Co., The, 2131 Bueter Road, Fort Wayne 4, Ind.
Maguire Industries, Inc., Electronics Dept., Bridgeport, Conn.
Milwaukee Stamping Co., 824 S. 72nd St., Milwaukee, Wisc.
National Diecasting Co., 3601 W. Touhy St., Newark, N. J.
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Philco Corp., Tioga & C Sts., Philadelphia 3, Pa.
Precise Development Parts, 28 N. Loomis St., Chicago, Ill.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Seeburg Corp., J. P., 1510 N. Dayton St., Chicago, Ill.
Sparkes Mfg. Co., 318 Jefferson St., Newark, N. J.
Talking Devices Co., 4447 W. Irving Park Rd., Chicago, Ill.
Trav-Ler Karenola Radio & Television Corp., 1028 W. Van Buren St., Chicago, Ill.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago 47, Ill.
Wilcox Gay Corp., Charlotte, Mich.
Wurlitzer Mfg. Co., Rudolph, North Tonawanda, N. Y.

Changers, Frequency

see Vibrators

Chassis

see Cabinets

Chokes

POWER and AUDIO CHOKES

Advance Transformer Co., 14 N. May St., Chicago, Ill.
Airdesign & Fabrication, Inc., 241 Fairfield Ave., Upper Darby, Pa.
Altec Lansing Corp., 1680 N. Vine St., Los Angeles 28, Calif.
American Communications Corp., 306 Broadway, New York, N. Y.
American Transformer Co., 178 Emmett St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Aray Mfg. & Supply Co., Inc., 3107 Pine St., St. Louis 3, Mo.
Audio Development Co., 2833-13th Ave S., Minneapolis 7, Minn.
Automatic Winding Co., 900 Passaic Ave., E. Newark, N. J.
Best Mfg. Co., Inc., 1200 Grove St., Irvington 1, N. J.
Chicago Transformer Div., Essex Wire Corp., 3501 W. Addison St., Chicago 18, Ill.
Coto-Coil Company, Inc., 65 Pavilion Ave., Providence, R. I.
Davis & Co., Inc., Dean W., Kentland, Ind.
Dinion Coil Co., Inc., 1 North St., Caledonia, N. Y.
Dongan Electric Mfg. Co., 2987 Franklin Street, Detroit, Mich.
DX Crystal Co., 1200 N. Claremont Ave., Chicago, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electronic Engineering Co., 3223 West Armitage Ave., Chicago, Ill.
Electronic Transformer Co., 207 W. 25th St., New York, N. Y.
Electronic Winding Co., 5031 Broadway, Chicago 40, Ill.
Essex Electronics, 1060 Broad St., Newark, 2, N. J.
Federal Instrument Co., 3931-47th Ave., Long Island City 4, N. Y.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Foster Co., A. P., 719 Wyoming Ave., Lockland 15, Ohio
Franklin Transformer, 65 22nd Ave. N.E., Minneapolis 13, Minn.
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
Gardner Electric Mfg. Co., 4227 Hollis St., Emeryville 8, Calif.
General Electric Co., Schenectady 5, N. Y.
General Transformer Corp., 1250 W. Van Buren St., Chicago 7, Ill.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb.
Gramer Co., 2734 N. Pulaski Rd., Chicago, 39, Ill.
Guided Radio Corp., 161 Sixth Ave., New York 13, N. Y.
Hadley Co., Robert M., 711 E. 61st St., Los Angeles, Calif.
Halldorson Co., The, 4500 Ravenswood Ave., Chicago 28, Ill.
Hardwick, Hindle, Inc., 40 Hermon St., Newark, N. J.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
Hollywood Transformer Co., 645 N. Martel Ave., Los Angeles 36, Cal.
Hudson American Corp., 25 W. 43rd St., New York, N. Y.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Insuline Corp. of America, 36-20 35th Ave., Long Island City, N. Y.
International Transformer Co., 396 Broadway, New York, N. Y.
Jefferson Electric Co., Bellwood, Ill.
Kenyon Transformer Co., 840 Barry St., New York 59, N. Y.
Langevin Co., Inc., 37 W. 65th St., New York, N. Y.
Lectrohm, Inc., 5125 W. 25th St., Cicero, 50, Ill.
Madison Electrical Products Corp., Madison, N. J.
Magnetic Windings Co., Div. Essex Wire Corp., 416 South 16th St., Easton, Pa.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Merit Coil & Transformer Corp., 4427 N. Clark St., Chicago 40, Ill.
Muter Co., 1255 S. Michigan Ave., Chicago, Ill.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles 1, Calif.
Philmore Mfg. Co., 113 University Pl, New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radionic Controls, 3758 Belmont Ave., Chicago 18, Ill.
Radionic Transformer Co., 411 S. Sangamon St., Chicago, Ill.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Red Arrow Electric Corp., 100 Colt St., Irvington, N. J.
Rola Co., Inc., 2530 Superior Ave., Cleveland, Ohio
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South Pasadena, Calif.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Standard Transformer Corp., 1500 N. Halstead St., Chicago, Ill.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Telex Products Co., Telex Park, Minneapolis 1, Minn.
Thermador Elec. Mfg. Co., 5119 S. Riverside Drive, Los Angeles 22, Calif.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
Transformer Products, Inc., 143 W. 51 St., New York, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Walsh Engineering Co., 34 DeHart Place, Elizabeth, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.

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ELECTRONIC and ALLIED PRODUCTS

Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

R. F. and I. F. CHOKES

Aladdin Radio Industries, Inc., 501 W. 35th St., Chicago 16, Ill.
Albion Coil Co., Albion, Ill.
Automatic Winding Co., 900 Passaic Ave., E. Newark, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Best Mfg. Co. Inc., 1200 Grove St., Irvington, N. J.
Bridgeport Mfg. Co., Bridgeport, Ill.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Burnett Radio Lab., Wm. W. L., 4814 Idaho St., San Diego, Calif.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Coto-Coil Company Inc., 65 Pavilion Ave., Providence, R. I.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electronic Products Mfg. Co., 7300 Huron River Drive, Dexter, Michigan
Electronic Winding Co., 5031 Broadway Chicago 40, Ill.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Essex Electronics, 1060 Broad St., Newark 2, N. J.
Fast & Co., John E., 3101 N. Pulaski Road, Chicago 41, Ill.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
Ferranti Electric Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Gardner Electric Mfg. Co., 4227 Hollis St., Emeryville 8, Calif.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
General Winding Co., 420 West 45th St., New York, N. Y.
Gold Shield Products, 25 W. Broadway, New York 7, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Guthman & Co., E. I., 15 S. Throop St., Chicago, Ill.
Hammarlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
Hudson American Corp., 25 W. 43rd St., New York, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Lectrohm, Inc., 5125 W. 25th St., Cicero, 50, Ill.
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton 5, N. J.
Madison Electrical Products Corp., Madison, N. J.
Meissner Mfg. Div., Maguire Industries Inc., Mt. Carmel, Ill.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Miller Co., J. W., 5917 S. Main St., Los Angeles, Cal.
Muter Company, 1255 S. Michigan Ave., Chicago, Ill.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago 44, Ill.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radionic Transformer Co., 411 S. Sangamon St., Chicago, Ill.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Sickles Co., F. W., 165 Front St., Chicopee, Mass.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Sonora Radio & Television Corp., 2626 W. Washington St., Chicago 28, Ill.
Sound Equipment Corp., of California, 3903 San Fernando Road, Glendale 4, Calif.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.
Stanwyck Winding Co., 102 S. Lander St., Newburgh, N. Y.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Teleradio Engineering Corp., 99 Wall St., New York 5, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

Clips & Clamps

TEST & TUBE CLIPS AND CLAMPS

Aircraft-Marine Prods. Inc., 1523 North Fourth St., Harrisburg, Pa.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway. S., Mt. Vernon, N. Y.
Birnbach Radio Co, Inc., 145 Hudson St., New York, N. Y.
Birtcher Corp., 5087 Huntington Drive, Los Angeles 32, Calif.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Dante Electric Mfg. Co., Bantam, Conn.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2460 W. George St., Chicago 18, Ill.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Morse Co., Frank W., 301 Congress St., Boston 10, Mass.
Mueller Electric Co., 1583 E. 31st St., Cleveland 14, Ohio
National Co., Inc., 61 Sherman St., Malden 48, Mass.
Penn-Union Electric Corp., 315 State St., Erie, Pa.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Reliable Spring & Wire Forms Co., 3167 Fulton Road, Cleveland 9, Ohio
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Thompson Corp., Geo. S., 5240 Huntington Drive, Los Angeles 32, Calif.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Wood Electric Co., Inc., C. D., 826 Broadway, New York 3, N. Y.
Zierick Mfg. Corp., 385 Gerard Ave., New York, N. Y.

Coils

POWER and A. F. COILS and WINDINGS

Advance Transformer Co., 14 N. May St., Chicago, Ill.
Airdesign & Fabrication, Inc., 241 Fairfield Ave., Upper Darby, Pa.
Aladdin Radio Industries, Inc., 501 West 35th St., Chicago 16, Ill.
Altec Lansing Corp., 1680 N. Vine St., Los Angeles 28, Calif.
American Transformer Co., 178 Emmett St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Automatic Mfg. Corp., 900 Passaic Ave., E. Newark, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Best Mfg. Co., Inc., 1200 Grove St., Irvington 1, N. J.
Bittermann Electric Co., 50 Henry St., Brooklyn, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Carron Mfg. Co., 415 S. Aberdeen St., Chicago, Ill.
Communication Parts, 1101 N. Paulina St., Chicago 22, Ill.
Coto-Coil Company, Inc., 65 Pavilion Ave., Providence, R. I.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Dano Electric Co., 93 Main St., Winsted, Conn.
Davis & Co., Dean W., Kentland, Ind.
Dinion Coil Co., Inc., 1 North St., Caledonia, N. Y.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electrical Specialty Co., 2304 Washington St., Boston, Mass.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
Electronic Winding Co., 5031 Broadway, Chicago 40, Ill.
Essex Electronics, 1060 Broad St., Newark 2, N. J.
Federal Instrument Co., 3931-47th Ave., Long Island City 4, N. Y.
Ferranti Electric Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Foster Co., A. P., 719 Wyoming Ave., Lockland 15, Ohio
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
Gardner Electric Mfg. Co., 4227 Hollis St., Emeryville 8, Calif.
General Electric Co., Schenectady 5, N. Y.
General Winding Co., 420 West 45th St., New York, N. Y.
Giannini & Co., Inc., G. M., 161 E. California St., Pasadena, Calif.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Gramer Co., 2734 N. Pulaski Rd., Chicago, 39, Ill.
Hadley Co., Robert M., 711 East 61st St., Los Angeles, Calif.
Halldorson Company, The, 4500 Ravenswood Ave., Chicago 28, Ill.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Avenue, Brooklyn 7, N. Y.
Hollywood Transformer Co., 645 N. Martel Ave., Los Angeles 36, Calif.
Hudson American Corp., 25 West 43rd St., New York, N. Y.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Instrument Resistors Co., Little Falls, N. J.
International Transformer Co., 396 Broadway, New York, N. Y.
Johnson Co., E. F., Waseca, Minn.
Langevin Co., Inc., 37 W. 65th St., New York, N. Y.
Lawton Products Co., Inc., 624 Madison Ave., New York 22, N. Y.
Magnetic Windings Co., Div. of Essex Wire Corp., 416 South 16th St., Easton, Pa.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Merit Coil & Transformer Corp., 4427 N. Clark St., Chicago 40, Ill.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Northeifer Winding Labs., 111 Albermarle Ave., Trenton, N. J.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles 1, Calif.
Philco Co., Tioga & C Sts., Philadelphia 34, Pa.
Presto Electric Co., 4511 New York Ave., Union City, N. J.
Printloid, Inc., 95 Mercer St., New York, 12, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radionic Controls, 3758 Belmont Ave., Chicago 18, Ill.
Radionic Transformer Co., 411 S. Sangamon St., Chicago, Ill.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rola Co., Inc., 2530 Superior Ave., Cleveland, Ohio
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Sandman Electric Motor Co., 164 Oliver St., Boston 10, Mass.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South Pasadena, Calif.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.

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Standard Transformer Corp., 1500 N. Halsted St., Chicago, Ill.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Teleradio Engineering Corp., 99 Wall St., New York 5, N. Y.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
Transformer Products, Inc., 143 W. 51st St., New York, N. Y.
Tungsten Contact Mfg. Co., North Bergen, N. J.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Walsh Engineering Co., 34 DeHart Place, Elizabeth, N. J.
Webster Electric Co., 1900 Clark St., Racine, Wis.
Weller Mfg. Co., 516 Northampton St., Easton, Pa.
Wellman Mfg. Co., 7122 Melrose Ave., Los Angeles 46, Calif.
Western Electric Co. Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburg, Pa.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Whisk Laboratories, 87 Malden Lane, New York 7, N. Y.
Wickwire Spencer Metallurgical Corp., 260 Sherman St., Newark, N. J.

R. F. RECEIVING or TRANSMITTING COILS

Advance Transformer Co., 14 N. May St., Chicago, Ill.
Aero Communications, Inc., 231 Main St., Hempstead, L. I., N. Y.
Aladdin Radio Industries, Inc., 501 W. 35th St., Chicago 16, Ill.
Albion Coil Co., Albion, Ill.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Communications Corp., 306 Broadway, New York, N. Y.
American Transformer Co., 178 Emmett St., Newark, N. J.
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Andrew Co., 363 E. 75th St., Chicago 19, Ill.
Aray Mfg. & Supply Co., Inc., 3107 Pine St., St. Louis 3, Mo.
Automatic Mfg. Corp., 900 Passaic Ave., E. Newark, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bittermann Electric Co., 50 Henry St., Brooklyn, N. Y.
Bridgeport Mfg. Co., Bridgeport, Ill.
Burnett Radio Lab., Wm. W. L., 4814 Idaho St., San Diego, Calif.
Carron Mfg. Co., 415 S. Aberdeen St., Chicago, Ill.
Communication Parts, 1101 N. Paulina St., Chicago 22, Ill.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Coto-Coil Company, Inc., 65 Pavilion Ave., Providence, R. I.
Dinion Coil Co., Inc., 1 North St., Caledonia, N. Y.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Electrical Reactance Corp., Franklinville, N. Y.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electrical Specialty Co., 2304 Washington St., Boston, Mass.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electronic Transformer Co., 207 West 25th Street, New York, N. Y.
Electronic Winding Co., 5031 Broadway, Chicago 40, Ill.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Erco Radio Labs., Inc., Fenimore Ave., Hempstead, N. Y.
Essex Electronics, 1060 Broad St., Newark 2, N. J.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
Ferranti Electric Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Gardner Electric Mfg. Co., 4227 Hollis St., Emeryville 8, Calif.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
General Winding Co., 420 West 45th St., New York, N. Y.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Guthman & Co., E. I., 15 So. Throop St., Chicago, Ill.
Hammarlund Mfg. Co. Inc., 460 W. 34th St., New York 1, N. Y.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Johnson Co., E. F., Waseca, Minn.
Langevin Co., Inc., 37 W. 65th St., New York, N. Y.
Lawton Products Co., 624 Madison Ave., New York 22, N. Y.
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton 5, N. J.
Malco Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Meissner Mfg. Div., Maguire Industries, Inc., Mount Carmel, Ill.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Miller Co., J. W., 5917 S. Main St., Los Angeles, Cal.
Monarch Mfg. Co., 2014 N. Major Ave., Chicago, Ill.
Muter Co., 1255 S. Michigan Ave., Chicago, Ill.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Philco Corp., Tioga & C Sts., Philadelphia 34, Pa.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Printloid, Inc., 95 Mercer St., New York 12, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Craftsmen, 1341 So. Michigan Ave., Chicago 5, Ill.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Ross Mfg. Co., 2241 S. Indiana Ave., Chicago 27, Ill.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Sandman Electric Motor Co., 164 Oliver St., Boston 10, Mass.
Sickles Co., F. W., 165 Front St., Chicopee, Mass.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Sonora Radio & Television Corp., 2626 W. Washington St., Chicago 28, Ill.
Sound Equipment Corp. of California, 3903 San Fernando Road, Glendale 4, Calif.
Standard Coil Products Co., 2329 N. Pulaski Road, Chicago 18, Ill.
Standard Winding Corp., 44-62 Johnes St., Newburgh, N. Y.
Stanwyck Winding Co., 102 South Lander St., Newburgh, N. Y.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Teleradio Engineering Corp., 99 Wall St., New York 5, N. Y.
Transmitter Equipt. Mfg. Co. Inc., 345 Hudson St., New York 14, N. Y.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.

SOLENOID COILS

Advance Transformer Co., 14 N. May St., Chicago, Ill.
Airdesign & Fabrication Inc., 241 Fairfield Ave., Upper Darby, Pa.
Aladdin Radio Industries, Inc., 501 West 35th St., Chicago 16, Ill.
Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee, Wis.
Allied Control Co., Inc., 2 East End Ave., New York 10, N. Y.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Automatic Mfg. Corp., 900 Passaic Ave., E. Newark, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.
Carron Mfg. Co., 415 S. Aberdeen St., Chicago, Ill.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Communications Parts, 1101 N. Paulina St., Chicago 22, Ill.
Consolidated Radio Products Co., 350 W. Erie St., Chicago 10, Ill.
Coto-Coil Company, Inc., 65 Pavilion Ave., Providence, R. I.
Davis & Co., Dean W., Kentland, Ind.
Dinion Coil Co., Inc., 1 North St., Caledonia, N. Y.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electric Auto-Lite Co., Toledo 1, Ohio
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electrical Coil Winding Co., 2733 Saunders St., Camden, N. J.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
Electronic Winding Co., 5031 Broadway, Chicago 40, Ill.
Essex Electronics, 1060 Broad St., Newark 2, N. J.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Foster Co., A. P., 719 Wyoming Ave., Lockland 15, Ohio
Gardner Electric Mfg. Co., 4227 Hollis St., Emeryville 8, Calif.
General Electric Co., Schenectady 5, N. Y.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Gramer Co., 2734 N. Pulaski Rd., Chicago 39, Ill.
Guardian Electric Mfg. Co., 1400 Washington Blvd., Chicago 7, Ill.
Hadley Co., Robert M., 711 East 61st St., Los Angeles, Calif.
Halldorson Co., The, 4500 Ravenswood Ave., Chicago 28, Ill.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Avenue, Brooklyn 7, N. Y.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Instrument Resistors Co., Little Falls, N. J.
International Transformer Co., 396 Broadway, New York, N. Y.
Jefferson Electric Co., Bellwood, Ill.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Langevin Co., Inc., 37 West 65th St., New York, N. Y.
Leotone Radio Co., 65 Dey St., New York 7, N. Y.
Madison Electrical Prods. Corp., Madison, New Jersey
Magnavox Co., The, 2131 Bueter Rd., Fort Wayne 4, Ind.
Magnetic Windings Co., Div. of Essex Wire Corp., 416 South 16th St., Easton, Pa.
Malco Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
National Co. Inc., 61 Sherman St., Malden 48, Mass.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Northelfer Winding Labs., 111 Albermarle Ave., Trenton, N. J.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Parker Engineering Products Co., 16 W. 22nd St., New York 10, N. Y.
Presto Electric Co., 4511 New York Ave., Union City, N. J.
R. B. M. Mfg. Co., Div. of Essex Wire Corp., Logansport, Ind.
Radionic Controls, 3758 Belmont Ave., Chicago 18, Ill.
Radionic Transformer Co., 411 S. Sangamon St., Chicago, Ill.
Red Arrow Electric Corp., 100 Colt St., Irvington, N. J.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Sandman Electric Motor Co., 164 Oliver St., Boston 10, Mass.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South Pasadena, Calif.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.
Standard Winding Co., 44-62 Johnes St., Newburgh, N. Y.
Thermador Elec. Mfg. Co., 5119 S. Riverside Drive, Los Angeles 22, Calif.
Transformer Products, Inc., 143 W. 51st St., New York, N. Y.

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Trebor Radio Co., Pasadena, Calif.
Tungsten Contact Mfg. Co., North Bergen, N. J.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Universal X-Ray Products Inc., 1800 North Francisco Ave., Chicago 47, Ill.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Webster Electric Co., 1900 Clark St., Racine, Wisc.
Weller Mfg. Co., 516 Northampton St., Easton, Pa.
Wellman Manufacturing Co., 7122 Melrose Ave., Los Angeles 46, Calif.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

Coil Winding Machines

see Machines

Colorimeters

PHOTO-ELECTRIC COLORIMETERS

Central Scientific Co., 1700 Irving Park Blvd., Chicago 13, Ill.
Coleman Electric Co., 318 Madison St., Maywood, Ill.
DeJur Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Electronic Products Co., 19 North First St., Geneva, Ill.
Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.
Gamma Instrument Co., Inc., 95 Madison Ave., New York 16, N. Y.
General Electric Co., Schenectady, N. Y.
Leitz, Inc., E., 730 Fifth Ave., New York 19, N. Y.
Pfaltz & Bauer, Inc., 350 Fifth Ave., New York, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y.
Pho-Tron Instrument Co., 5713 Euclid Ave., Cleveland, Ohio
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Saxl Instrument Co., 38-40 James St., East Providence 14, R. I.
Schaar & Co., 754 W. Lexington St., Chicago 7, Ill.
Scientific Glass Apparatus Co., Bloomfield, N. J.
Technical Products Co., 158 Madison Ave. at 3rd St., Memphis, Tenn.
White Research, 899 Boylston St., Boston, Mass.
Wilkens-Anderson Co., 111 N. Canal St., Chicago 6, Ill.

Comparators

see Analyzers, Surface

see Meters, pH

Condensers

see Capacitors

Connectors

CABLE CONNECTORS and COUPLINGS

A. B. C. Products, Inc., 11952 Montana Ave., W. Los Angeles 24, Calif.
Air Shields, Inc., Hatboro, Pa.
Airadio, Inc., Melrose Ave. & Battery Pl., Stamford, Conn.
Aircraft-Marine Prods., Inc., 1523 N. Fourth St., Harrisburg, Pa.
Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
Aircraft Radio Corp., Boonton, N. J.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Radio Hardware Co. Inc., 152 MacQuesten Pkway, S., Mt. Vernon, N. Y.
Andrew Co., 363 E. 75 St., Chicago 19, Ill.
Astatic Corp., 830 Market St., Conneaut, Ohio
Atlas Products Corp., 30 Rockefeller Plaza, New York 20, N. Y.
Atlas Sound Corp., 1443 39th St., Brooklyn, N. Y.
Automatic Metal Products Co., 315 Berry St., Brooklyn, N. Y.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Burndy Engineering Co., 107 Bruckner Blvd., New York 54, N. Y.
Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Connector Division, International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Dante Electric Mfg. Co., Bantam, Conn.
Diamond Instrument Co., North Ave., Wakefield, Mass.
Dossert & Co., 249 Huron St., Bklyn, N. Y.
Eby, Inc., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Electric Service Mfg. Co., 17th & Cambria St., Philadelphia 32, Pa.
Federal Mfg. & Engrg. Corp., 199-217 Steuben St., Brooklyn, N. Y.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 S. Hoover St., Los Angeles 7, Calif.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Harwood Co., Division of Los Angeles Corp., 540 N. La Brea, Los Angeles 36, Calif.
Heyman Mfg. Co., Kenilworth, N. J.
Hubbell, Inc., Harvey, Bridgeport 2, Conn.
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.
Ilsco Copper Tube & Product Inc., Mariemont Ave., Mariemont 27, Ohio
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Isolantite Inc., 343 Cortlandt St., Belleville 9, N. J.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2460 W. George St., Chicago 18, Ill.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kings Electronics Co., 372 Classon Ave., Brooklyn 5, N. Y.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Lapp Insulator Co., LeRoy, N. Y.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Mendelsohn Speedgun Co., 457 Bloomfield Ave., Bloomfield, N. J.
Monowatt Electric Corp., 66 Bissell St., Providence 7, R. I.
Morse Co., Frank W., 301 Congress St., Boston 10, Mass.
National Electronic Mfg. Corp., 22-78 Steinway Street, Long Island City 5, N. Y.
National Fabricated Products, 2650 Belden Ave., Chicago 47, Ill.
Northam Warren Corp., Stamford, Conn.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Oxford-Tartak Radio Corp., 3911 S. Michigan Ave., Chicago 15, Ill.
O. Z. Electrical Mfg. Co., 262 Bond St., Brooklyn, N. Y.
Penn-Union Electric Corp., 315 State St., Erie, Pa.
Precision Specialties, 220 North Western Ave., Los Angeles, Calif.
Pyle-National Co., 1334 N. Kostner Ave., Chicago 51, Ill.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif.
Rice's Sons, Inc., Bernard, 325 Fifth Ave., New York, N. Y.
Selectar Mfg. Co., 21-10 49th Ave., Long Island City, N. Y.
Sherman Mfg. Co., H. B., 22 Barney St., Battle Creek, Mich.
Stamford Metal Specialty Co., 428 Broadway, New York 13, N. Y.
Techno-Scientific Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
Thomas & Betts Co., Inc., 36 Butler St., Elizabeth 1, N. J.
Trumbull Electric Mfg. Co., Plainville, Conn.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Wood Electric Co., Inc., C. D., 826 Broadway, New York 3, N. Y.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.
Zierick Mfg. Corp., 385 Gerard Ave., New York, N. Y.

Contacts

see Points

Contactors

Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Allied Control Co., Inc., 2 East End Ave., New York 10, N. Y.
Arrow-Hart & Hegeman Elec. Co., 103 Hawthorn St., Hartford, Conn.
Automatic Electric Mfg. Co., 10 State St., Mankato, Minn.
Automatic Metal Products Corp., 315 Berry St., Brooklyn, N. Y.
Cutler-Hammer Inc., 315 North 12th St., Milwaukee 1, Wisc.
Connecticut Telephone Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
G-M Laboratories, Inc., 4313 N. Knox Ave., Chicago 32, Ill.
General Electric Co., Schenectady 5, N. Y.
Graphite Metallizing Corp., 1055 Nepperhan Ave., Yonkers 3, N. Y.
Guardian Electric Mfg. Co., 1400 Washington Blvd., Chicago 7, Ill.
Hart Mfg. Co., 110 Bartholomew Ave., Hartford 1, Conn.
Johnson Co., E. F., Waseca, Minn.
Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Calif.
Monitor Controller Co., 51 S. Gay St., Baltimore 2, Md.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Tork Clock Co., 1 Grove St., Mt. Vernon, N. Y.
Trumbull Electric Mfg. Co., Plainville, Conn.
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
Warrick, Charles F., 16251 Hamilton Ave., Detroit 3, Mich.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

Controls

ATTENUATORS

Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Centralab Div., Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Cinema Engineering Co., 1508 W. Verdugo Ave., Burbank, Calif.
Clarostat Mfg. Co., Inc., 130 Clinton Street, Brooklyn 1, N. Y.
Collins Radio Co., 855-35th St. N.E., Cedar Rapids, Iowa
Daven Co., 191 Central Ave., Newark 4, N. J.
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electronic Components, 423 N. Western Ave., Los Angeles 4, Calif.
Electronic Products Co., 19 North First St., Geneva, Ill.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Madison Electrical Products Corp., Madison, N. J.
Malco Co., Inc., 25 North 3rd St., Minneapolis, Minn.

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Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago 44, Ill.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rowe Radio Research Laboratory Co., 2422 N. Pulaski Rd., Chicago 39, Ill.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Stokes Rubber Co., Jos., Taylor & Webster Sts., Trenton, N. J.
Tech Laboratories, 7 Lincoln St., Jersey City, N. J.
Trefz Manufacturing Co., 38-11 Main St., Flushing, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
White Research, 899 Boylston St., Boston, Mass.

MOTOR CONTROLS

Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
General Electric Co., Schenectady 5, N. Y.
Hetherington & Son, Inc., Robert, Sharon Hill, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Yardeny Engrg. Co., 105 Chambers St., New York, N. Y.

VOLUME and TONE CONTROLS

Allen Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Centralab Div., Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Chicago Telephone Supply Co., 1142 W. Beardsley Ave., Elkhart, Ind.
Clarostat Mfg. Co., Inc., 130 Clinton Street, Brooklyn 1, N. Y.
Daven Co., 191 Central Ave., Newark 4, N. J.
DeJur Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Stackpole Carbon Co., St. Marys, Pa.
Stokes Rubber Co., Jos., Taylor & Webster Sts., Trenton, N. J.
Tech Laboratories, 7 Lincoln St., Jersey City, N. J.
Trefz Manufacturing Co., 38-11 Main St., Flushing, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Wirt Co., 5521 Greene St., Philadelphia, Pa.
Wurlitzer Mfg. Co., Rudolph, North Tonawanda, New York

WELDING CONTROLS

see Timers, Welding

Converters

ROTARY CONVERTERS

see Generators

VIBRATOR TYPE

ABC Radio Laboratories, 3334 N. New Jersey St., Indianapolis 5, Ind.
American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
Electronic Laboratories Inc., Indianapolis, Ind.
Electronic Measurements Co., Red Bank, N. J.
James Vibrapower Co., 1551 Thomas St., Chicago 22, Ill.
Kurman Electric Co., 135-18-37th St., Long Island City 1, N. Y.
Mallory & Co., P. R., Inc., 3029 E. Washington St., Indianapolis 6, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Richardson-Allen Corp., 15 West 20th, New York 11, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.

Cores

COMPLETE LAMINATED

Westinghouse Electric Corp., East Pittsburgh, Pa.

POWDERED IRON CORES

Aladdin Radio Industries, Inc., 501 W. 35th St., Chicago 16, Ill.
American Brass Co., Waterbury 88, Conn.
Crowley & Co., Inc., H. L., 1 Central Ave., West Orange, N. J.
Electro Products Laboratories, 549 W. Randolph St., Chicago, Ill.
Mallory Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Micro-Ferrocart Products Div., Maguire Industries, Inc., Greenwich, Conn.
Moraine Products Div., General Motors Corp., Dayton, Ohio
National Moldite Co., 25 Montgomery St., Hillside 5, N. J.
Pyroferric Corp., 175 Varick St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Stackpole Carbon Co., St. Marys, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Couplings

COAXIAL CABLE COUPLINGS

see Connectors

Crystals

CRYSTAL FINISHING EQUIPMENT

Consolidated Diamond Saw Blade Co., 320 Yonkers Ave., Yonkers 2, N. Y.
Cryco, Inc., 1516 Mission St., South Pasadena, Calif.
Diamond Tool Replacements, Div. of Oscap Mfg. Co., Inc., 207 W. Saratoga St., Baltimore 1, Md.
Felker Mfg. Co., 1132 Border Ave., Torrence, Calif.
Finch Telecommunications, Inc., Passaic, N. J.
General Crystals Corp., 1775 Foster Ave., Schenectady, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb.
Hunt & Sons, G. C., 544 Hanover, Carlisle, Pa.
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, L. I., N. Y.
Leuck Crystal Laboratory, 245 South 11th St., Lincoln 8, Nebr.
Leiman Bros., 203 Christie St., Newark 5, N. J.
Linick & Co., Leslie L., 29 E. Madison St., Chicago, Ill.
Martindale Electric Co., 617 Edgewater Br., Cleveland, Ohio
Merkle-Korff Gear Co., 213 N. Morgan St., Chicago 7, Ill.
National Research Corp., Vacuum Engineering Div., 100 Brookline Ave., Boston 15, Mass.
Piezo Electric Prods. Co., 104 Fifth Ave., Brooklyn Park, Baltimore 25, Md.
Plastic Fabricators Co., 440 Sansome St., San Francisco, Calif.
Volkel Bros. Machine Works, 1943 W. Manchester, Los Angeles 44, Calif.
Vreeland Mfg. Co., 2020 Southwest Jefferson St., Portland 1, Oregon

QUARTZ CRYSTALS and HOLDERS

Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kansas
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Jewels Corp., Attleboro, Mass.
Bassett, Inc., Rex, 500 S. E. Second St., Fort Lauderdale, Fla.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Beaumont Electric Supply Co., 1304 S. Indiana Ave., Chicago, Ill.
Bendix Radio Div., Bendix Aviation Corp., Baltimore 4, Md.
Bliley Electric Co., Erie, Pa.
Breon Laboratories, 607 Rose St., Williamsport, Pa.
Burnett Radio Lab., Wm. W. L., 4814 Idaho St., San Diego, Calif.
C. W. Mfg., 3300 Brooklyn Ave., Los Angeles 33, Calif.
Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass.
Carlisle Crystal Corp., 132 N. Hanover St., Carlisle, Pa.
Collins Radio Co., 855 35th St., N. E., Cedar Rapids, Iowa
Commercial Crystal Co., 112 N. Water St., Lancaster, Pa.
Commercial Equipment Co., 1416 McGee St., Kansas City, Mo.
Commercial Radio Equip. Co., 321 East Gregory Blvd., Kansas City 5, Mo.
Cryco, Inc., 1516 Mission St., S. Pasadena, Calif.
Crystal Laboratories, 801 W. Maple St., Wichita, Kansas
Crystal Products Co., 1519 McGee St., Kansas City 8, Mo.
Crystal Research Labs., Inc., 29 Allyn St., Hartford, Conn.
Dallons Laboratories, 5066 Santa Monica Blvd., Los Angeles, Calif.
Daughetee Mfg., 228 N. Clinton St., Chicago, Ill.
Diamond Drill Carbon Co., 63 Park Row, New York, N. Y.
Dow, L. A., 2208 4th Ave., Seattle, Wash.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Eidson's, 1309 N. Second St., Temple, Texas
Electric Appliances Inc., 120 W. North St., Indianapolis 4, Ind.
Electrical Prod. Corp., 950-30th St., Oakland 8, Calif.
Electronic Ind. (Ill.), Sandwich, Ill.
Electronic Ind. (Iowa), 517 Fourth Ave., S. E., Cedar Rapids, Iowa
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Elkay Radio Products, 305-309 E. Walnut St., Oglesby, Ill.
Etched Products Corp., 39-01 Queens Blvd., Long Island City, N. Y.
Federal Engineering Co., 37 Murray St., New York 7, N. Y.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Felsenthal & Sons, G., 4122 W. Grand Ave., Chicago 51, Ill.
Finch Telecommunications Inc., Passaic, N. J.
Franklin Transformer, 65 22nd Ave., N. E., Minneapolis 13, Minn.
Frequency Measuring, 1816 Walnut St., Kansas City, Mo.
Galvin Mfg. Corp., 4545 W. Augusta Blvd., Chicago 51, Ill.
General Ceramics & Steatite Corp., Keasbey, N. J.
General Crystal Corp., 1775 Foster Ave., Schenectady, N. Y.
General Electric Co., 1 River Road, Schenectady 5, N. Y.
General Piezo Co., 2614 State Ave., Kansas City, Kans.
General Quartz Lab., Cosmopolitan Bldg., Irvington on Hudson, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wis.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb.
Harvey Radio Labs., Inc., 447 Concord Ave., Cambridge, Mass.
Hatcher & Fisk, 125 Kansas Ave., Topeka, Kan.
Hearing Aid Lab., 1404 Franklin St., Michigan City, Ind.
Henney Motor Co., Gentleman Products Div., Freeport, Ill.

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Henry Mfg. Co., 10860 Santa Monica Blvd., Los Angeles 25, Calif.
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
Hipower Crystal Co., 2033 W. Charleston St., Chicago, Ill.
Hoffman Co., P. R., 321 Cherry St., Carlisle, Pa.
Hollister Crystal Co., Boulder, Colo.
Howard Mfg. Co., 15 Fourth St., Council Bluffs, Iowa
Hunt & Sons, G. C., 544 Hanover, Carlisle, Pa.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Jefferson Inc., Ray, 40 E. Merrick Rd., Freeport, Long Island, N. Y.
Jefferson Travis Radio Mfg. Corp., 245 East 23rd St., New York 10, N. Y.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Kemilte Laboratories, 1809 N. Ashland Ave., Chicago, Ill.
Keystone Piezo Co., 2143 W. Liberty Ave., Pittsburgh 16, Pa.
Knights Co., James, 131 S. Wells St., Sandwich, Ill.
Lenoxite Div., Lenox, Inc., 65 Prince St., Trenton, N. J.
Leuck Crystal Laboratory, 245 S. 11th St., Lincoln, Neb.
Link, Fred M., 125 W. 17th St., New York, N. Y.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Majestic Radio & Television Corp., 2600 W. 50th St., Chicago, Ill.
Meck Industries, John, Liberty St., Plymouth, Ind.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Miller, August E., 9226 Hudson Blvd., North Bergen, N. J.
Monitor Piezo Products Co., 815 Fremont St., South Pasadena, Cal.
National Co., 61 Sherman St., Malden 48, Mass.
National Electronic Mfg. Corp., 22-78 Steinway St., Long Island City 5, N. Y.
National Scientific Products Co., 5013 N. Kedzie Ave., Chicago 25, Ill.
North American Philips Co., Inc., 100 E. 42nd St., New York 17, N. Y.
Ogush, Inc., William B., 33 W. 60th St., New York, N. Y.
Pacific Clay Products Co., 306 West Avenue 26, Los Angeles 31, Calif.
Pacific Radio Crystal Co., 1035 Post St., San Francisco, Cal.
Pan-Electronics Laboratories, Inc., 498 Spring St., N. W., Atlanta, Ga.
Parisian Novelty Co., 3510 S. Western Ave. Ch,icago 9, Ill.
Petersen Radio Co., 2800 W. Broadway, Council Bluffs, Iowa
Philco Corp., Tioga & C Sts., Philadelphia 34, Pa.
Piezo Electric Products Co., 104 Fifth Ave., Brooklyn Park, Baltimore 25, Md.
Precision Piezo Service, 427 Mayflower St., Baton Rouge, La.
Premier Crystal Labs., Inc., 63 Park Row, New York, N. Y.
Quartz Lab., Inc., 1513 Oak St., Kansas City, Mo.
Quartz Products Co. of New York, 304 E. 45th St., New York, N. Y.
R. E. C. Mfg. Corp., 1250 Highland St., Holliston, Mass.
R-9 Crystal Co., Inc., 632 Grant St., Pittsburgh, Pa.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Specialty Mfg. Co., 403 N. W. 9th Ave., Portland, Oregon
Reeves Sound Lab., Inc., 62 W. 47th St., New York, N. Y.
Remler Co. Ltd., 2101 Bryant St., San Francisco 10, Calif.
Ross Mfg. Co., 2241 S. Indiana Ave., Chicago 27, Ill.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Scientific Radio Service, 4301 Sheridan St., University Park, Md.
Sentry Crystal Co., 206 S. W. Washington St., Portland 4, Ore.
Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y. (test equipment.)
Silicocks-Miller Co., 10 Parker Ave. W., South Orange, N. J.
Sipp-Eastwood Corp., 39 Keen St., Paterson, N. J.
Smith Lab., M. L., 16 Field St., Kane, Pa.
Somerset Laboratories, 306 Valleybrook Ave., Lyndhurst, N. J.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.
Standard Piezo Co., Woolworth Bldg., Carlisle, Pa.
Standard Plastics, 1548 S. Robertson Blvd., Los Angeles 35, Calif.
Telephonics Corp., 350 West 31st St., New York, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Union Piezo Corp., 701 McCarter Highway, Newark, N. J.
Universal Television System, 112 W. 18th St., Kansas City 8, Mo.
Valpey Crystals, Highland St., Holliston, Mass.
Wallace Mfg. Co., Wm. T., Chili & Madison Aves., Peru, Indiana
Wellman Mfg. Co., 7122 Melrose Ave., Los Angeles 46, Calif.
Western Electric Co., 120 Broadway, New York 5, N. Y.
Wilcox Elec. Co., 1400 Chestnut St., Kansas City, Mo.
Wynne Precision Co., 114½ N. Hill St., Griffin, Ga.

ROCHELLE SALT CRYSTALS

Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Tibbetts Laboratories, Camden, Maine
Western Electric Co. Inc., 120 Broadway, New York 5, N. Y.

Cutting Heads

see Recorders, Sound

Dial Lights

see Lights

Dials

see also Knobs, Pointers

Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway. S., Mt. Vernon, N. Y.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Austin Co., O., 42 Greene St., New York, N. Y.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bastian Bros. Co., 1600 N. Clinton Ave., Rochester, N. Y.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Cardy-Lundmark, 1801 West Bryon St., Chicago 13, Ill.
Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
Daven Co., 191 Central Ave., Newark 4, N. J.
Dearborn Glass Co., 2414 W. 21st St., Chicago, Ill.
Eastern Etching & Mfg. Co., Chicopee, Mass.
Emeloid Co., 291 Laurel Ave., Arlington, N. J.
Erie Resistor Corp., 644 W. 12th St., Erie, Pa.
Etched Products Corp., 39-01 Queens Blvd., Long Island City, N. Y.
Felsenthal & Sons, G., 4122 W. Grand Ave., Chicago 51, Ill.
Finch Telecommunications, Inc., Passaic, N. J.
Flock Process Co., 53 W. 31st St., New York 10, N. Y. (Also, 3 Quincy St., Norwalk, Conn.)
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Grammes & Sons, Inc., L. F., 389 Union St., Allentown 2, Pa.
Hopp Press, Inc., 460 W. 34th St., New York, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Kurz-Kasch Co., 1415 So. Broadway, Dayton 1, Ohio
Long Island Engraving Co., 19 West 21st St., New York 10, N. Y.
McInerney Plastic Co., 655 Godfrey Ave., S. W., Grand Rapids 1, Michigan
Marion Electrical Instrument Co., Manchester, N. H.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., 61 Sherman St., Malden, 48, Mass.
New England Etching & Plating Co., 25 Spring St., Holyoke, Mass.
New England Radiocrafters, 1156 Commonwealth Ave., Boston 34, Mass.
Parisian Novelty Co., 3510 S. Western Ave., Chicago 9, Ill.
Plastic Fabricators Co., 440 Sansome St., San Francisco 11, Calif.
Premier Metal Etching Co., 21-03 44th Ave., Long Island City, N. Y.
Printloid, Inc., 95 Mercer St., New York, N. Y.
Richardson Co., Melrose Park, Ill.
Screenmakers, 64 Fulton St., New York 1, N. Y.
Silk Screen Supplies, Inc., 33 Lafayette Ave., Brooklyn, N. Y.
Silicocks-Miller Co., 10 Parker Ave., W. South Orange, N. J.
Technical Radio Co., 275 Ninth St., San Francisco, Calif.
Waterbury Button Co., 835 S. Main St., Waterbury, Conn.
Worcester Moulded Plastics Co., 8 Grafton St., Worcester 8, Mass.

Direction Finders

see Radio Compass Receivers

Discs

BLANK RECORDING DISCS

Advance Recording Products Co., 36-12 34th St., Long Island City, N. Y.
Allied Recording Products Co., 21-09 43d Ave., Long Island City 1, N. Y.
Audio Devices, Inc., 444 Madison Ave., New York 22, N. Y.
Bakelite Corp., 30 East 42nd St., New York 17, N. Y.
Dearborn Glass Co., 2414 W. 21st St., Chicago, Ill.
Duotone Co., 799 Broadway, New York, N. Y.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Federal Recorder, Elkhart, Ind.
Galvin Mfg. Corp., 4545 W. Augusta Blvd., Chicago 51, Ill.
General Electric Co., Schenectady 5, N. Y.
Gould-Moody Co., 395 Broadway, New York, N. Y.
Gray Mfg. Co., 16-30 Arbor St., Hartford, Conn.
Home Recording Co., 9 E. 19th St., New York, N. Y.
Howard Radio Co., 1735 Belmont Ave., Chicago 13, Ill.
Memovox, Inc., 9242 Beverly Blvd., Beverly Hills, Calif.
Mirror Record Corp., 58 W. 25th St., New York, N. Y.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Sound Devices Co., 160 East 116th St., New York 20, N. Y.
SoundScriber Corp., The, 82 Audubon St., New Haven 11, Conn.
Speak-O-Phone Recording & Equipment Co., 23 W. 60th St., New York, N. Y.
Talking Devices Co., 4447 W. Irving Park Rd., Chicago, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wilcox Gay Corp., Charlotte, Mich.
Zephyr Products Corp., 160 E. 116th St., New York 29, N. Y.

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Discs, Rectifier

see Rectifiers

Dividers

VOLTAGE DIVIDERS

see Resistors, Wire Wound

Drafting Equipment

Alteneder Co., Theo., 1217 Spring Garden St., Philadelphia 23, Pa.
American Pencil Co., 500 Willow Ave., Hoboken, N. J.
American Photocopy Equipment Co., 2849 N. Clark St., Chicago, Ill.
Arkwright Finishing Co., Turks Head Bldg., Providence, R. I.
Bruning Co., Inc., Charles, 4700 Montrose Ave., Chicago 41, Ill.
Cardinell Corp., Montclair, N. J.
Carter's Ink Co., Cambridge, Mass.
Dietzgen Co., Eugene, 2425 Sheffield Ave., Chicago, Ill.
Dixon Crucible Co., Joseph, Jersey City, N. J.
Eagle Pencil Co., 703 East 13th St., New York, N. Y.
Eberhard Faber Pencil Co., 37 Greenpoint Ave., Brooklyn 22, N. Y.
Eclipse Moulded Products Co., 5151 North 32nd St., Milwaukee 9, Wisc.
Emmert Mfg. Co., Waynesboro, Pa.
Eraser Co., 231 W. Water St., Syracuse 2, N. Y.
Faber, Inc., A. W., 41 Dickerson St., Newark 4, N. J.
General Pencil Co., 67 Fleet St., Jersey City, N. J.
Gold Shield Products Co., 25 W. Broadway, New York 7, N. Y.
Higgins Ink Co., Inc., 271 Ninth St., Brooklyn 15, N. Y. (Drafting inks)
Holliston Mills, Inc., Norwood, Mass.
Hunter Electro Copyist, Inc., 430 S. Warren St., Syracuse, N. Y.
Keuffel & Esser Co., 300 Adams St., Hoboken, N. J.
Koh-I-Noor Pencil Co., Bloomsbury, N. J.
Ozalid Div., General Aniline & Film Corp., 770 Ansco Rd., Johnson City, N. Y.
Paragon-Revolute Corp., 97 South Ave., Rochester 4, N. Y.
Pease Company, C. F., 2601 W. Irving Park Rd., Chicago 18, Ill.
Photo Reproducing Eqpt. Co., Chatham, N. J.
Plastic Fabricators Co., 440 Sansome St., San Francisco 11, Calif.
Post Co., Frederick, 3650 Avondale Ave., Chicago 90, Ill.
Reliance Devices Co., Inc., 30 Irving Place, New York 3, N. Y.
Staedtler, J. S., Inc., 53-55 Worth St., New York, N. Y.
Starrett Co., L. S., 165 Crescent St., Athol, Mass.
Technical Products Co., 158 Madison at Third St., Memphis, Tenn.
United States Blue Print Paper Co., 207 S. Wabash Ave., Chicago, Ill.
Universal Drafting Machine Co., 1426 W. Third St., Cleveland 13, Ohio
Weber Co., F., 1220 Buttonwood St., Philadelphia 23, Pa.
White Co., David, 315 Court St., Milwaukee, Wisc.
Wickes Bros., 515 N. Washington St., Saginaw, Mich.
Williams, Brown & Earle, Inc., 918 Chestnut St., Philadelphia, Pa.

Dynamotors

see Generators

Enamels

see Finishes

Equalizers

see Filters

Escutcheons

see also Dials, Scales

Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Emblem Co., Utica, N. Y.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway. S., Mt. Vernon, N. Y.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Austin Co., O., 42 Greene St., New York, N. Y.
B. & C. Insulation Products Inc., 261 Fifth Ave., New York 16, N. Y.
Bastian Bros. Co., 1600 N. Clinton Ave., Rochester, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
Daven Co., 191 Central Ave., Newark 4, N. J.
Eastern Etching & Mfg. Co., Chicopee, Mass.
Emeloid Co., Inc., 291 Laurel Ave., Arlington, N. J.
Erie Resistor Corp., 644 W. 12 St., Erie, Pa.
Etched Products Corp., 39-01 Queens Blvd., Long Island City, N. Y.
Farley & Loetscher Mfg. Co., Dubuque, Iowa
Felsenthal & Sons, G., 4122 W. Grand Ave., Chicago 51, Ill.
Flock Process Co., 53 W. 21st St., New York 10, N. Y. (Also, 3 Quincy St., Norwalk, Conn.)
Gemloid Corp., 79-10 Albion Ave., Elmhurst, N. Y.
General Electric Co., Plastics Div., 1 Plastics Ave., Pittsfield, Mass.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Grammes & Sons, Inc., L. F., 389 Union St., Allentown 2, Pa.
Hopp Press, Inc., 460 West 34th St., New York, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Long Island Engraving Co., 19 West 21st St., New York 10, N. Y.
Meyercord Co., 5323 W. Lake St., Chicago, 44, Ill.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
New England Etching & Plating Co., 25 Spring St., Holyoke, Mass.
New England Radiocrafters, 1156 Commonwealth Ave., Boston 34, Mass.
Panelyte Div., St. Regis Paper Co., 230 Park Ave., New York, N. Y.
Photox Silk Screen Supply Co., 30 Irving Place, New York 3, N. Y.
Plastic Fabricators Co., 440 Sansome St., San Francisco 11, Calif.
Plastic Manufacturers, Inc., Stamford, Conn.
Premier Metal Etching Co., 21-03 44th Ave., Long Island City, N. Y.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Screenmakers, 64 Fulton St., New York 1, N. Y.
Sillcocks-Miller Co., 10 Parker Ave. W., South Orange, N. J.
Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N. Y.
Stamford Metal Specialty Co., 428 Broadway, New York 13, N. Y.
Syracuse Ornamental Co., 581 So. Clinton St., Syracuse, N. Y.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Victory Mfg. Co., 1722 W. Arcade Pl., Chicago 12, Ill.
Waters Conley Co., 501 First St. N. W., Rochester, Minn.

Facsimile

Alden Products Co., 117 N. Main St., Brockton 64, Mass.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bunnell & Co., J. H., 215 Fulton St., New York, N. Y.
Engineering Laboratories, Inc., 602 E. Fourth St., Tulsa 3, Okla.
Finch Telecommunications, Inc., Passaic, N. J.
General Electric Co., Schenectady 5, N. Y.
Gilfillan Bros., Inc., 1815 Venice Blvd., Los Angeles, Calif.
Hallicrafters Co., 2611 Indiana Ave., Chicago 16, Ill.
Megard Corp., 1601 S. Burlington St., Los Angeles, Calif.
Press Wireless, Inc., 1475 Broadway, New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
United States Television Mfg. Corp., 106 Seventh Ave., New York, N. Y.
Wilcox Gay Corp., Charlottle, Mich.

Fasteners & Fastening Devices

Adel Precision Products Corp., Burbank, Calif.
An-cor-lox Div., Laminated Shim Co., Inc., Union St., Glenbrook, Conn.
Automatic Nut Co., Inc., Lebanon, Pa.
Boots Aircraft Nut Corp., New Canaan, Conn.
Camloc Fastener Corp., 420 Lexington Ave., New York 17, N. Y.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Clark Bros. Bolt Co., Millidale, Conn.
Columbia Nut & Bolt Co., 945 Main St., Bridgeport, Conn.
Dzus Fasteners Co., Inc., Box 605, Babylon, Long Island, N. Y.
Elastic Stop Nut Corp. of America, 2371 Vauxhall Rd., Union, N. J.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
Hartford Machine Screw Co., Hartford, Conn.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Lamson & Sessions Co., 1971 West 85th St., Cleveland, Ohio
Manufacturers Screw Products, 270 W. Hubbard St., Chicago, Ill.
National Screw & Mfg. Co., 2440 E. 75th St., Cleveland 4, Ohio
Palnut Co., Inc., 77 Cordier St., Irvington 11, N. J.
Pittsburgh Screw & Bolt Corp., P. O. Box 1708, Pittsburgh, Pa.
Russell, Burdsall & Ward Bolt & Nut Co., Midland Ave., Port Chester, N. Y.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Security Locknut Corp., 630 S. Wabash Ave., Chicago 5, Ill.
Simmons Machine Tool Corp., Fastener Div., Albany 1, N. Y.
Standard Locknut & Lockwasher, Inc., 33-35 West St. Clair St., Indianapolis, Ind.
Standard Pressed Steel Co., Jenkintown, Pa.
Thomas & Betts Co., Inc., 36 Butler St., Elizabeth 1, N. J.
Thompson-Bremer & Co., 1640 W. Hubbard St., Chicago, Ill.
Tinnerman Products, Inc., 2106 Fulton Rd., Cleveland 13, Ohio
Union Aircraft Products Corp., 380 Second Ave., New York, N. Y.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.

Fibre

see Insulation

Filter Chokes

see Chokes, Power & Audio

Filters

ELECTRIC WAVE SECTION FILTERS

American Transformer Co., 178 Emmett St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Audio Development Co., 2833 13th Ave. S., Minneapolis 7, Minn.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, North Hollywood, Calif.

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ELECTRONIC and ALLIED PRODUCTS

Best Mfg. Co., Inc., 1200 Grove St., Irvington 1, N. J.
Chicago Transformer Div., Essex Wire Corp., 3501 W. Addison St., Chicago 18, Ill.
Electronic Engineering Co., 3223 West Armitage Ave., Chicago, Ill.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Foster Co., A. P., 719 Wyoming Ave., Lockland 15, Ohio
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hollywood Transformer Co., 645 N. Martel Ave., Los Angeles 36, Calif.
International Transformer Co., 396 Broadway, New York, N. Y.
Kenyon Transformer Co., 840 Barry St., New York 59, N. Y.
Lavoie Laboratories, Morganville, N. J.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Techno-Scientific Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago, Ill.
Transformer Products, Inc., 143 W. 51st St., New York, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.

EQUALIZER FILTERS

Airdesign & Fabrication, Inc., 241 Fairfield Ave., Upper Darby, Pa.
Altec Lansing Corp., 1680 N. Vine St., Los Angeles 28, Calif.
American Transformer Co., 178 Emmett St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Audio Development Co., 2833 13th Ave. S., Minneapolis 7, Minn.
Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Daven Co., 191 Central Ave., Newark 4, N. J.
Electronic Engineering Co., 3223 West Armitage Ave., Chicago, Ill.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
Ferranti Electric Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
Hollywood Transformer Co., 645 N. Martel Ave., Los Angeles 36, Calif.
International Transformer Co., 396 Broadway, New York, N. Y.
Kenyon Transformer Co., 840 Barry St., New York 59, N. Y.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Simpson Mfg. Co., Inc., Mark, 188 West Fourth St., New York, N. Y.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
Transformer Products, Inc., 143 W. 51st St., New York, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.

NOISE FILTERS

Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
American Television & Radio Co., 300 East Fourth St., St. Paul 1, Minn.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Automatic Mfg. Co., 900 Passaic Ave., E. Newark, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, North Hollywood, Calif.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Continental Carbon, Inc., 13900 Lorain Ave., Cleveland, Ohio
Cornell-Dubilier Electric Corp., 1000 Hamilton Blvd., South Plainfield, N. J.
Deutschmann Corp., Tobe, Canton, Mass.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
Erie Resistor Corp., 644 West 12th St., Erie, Pa.
Fast & Co., John E., 3101 N. Pulaski Rd., Chicago 41, Ill.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Freed Radio Corp., 200 Hudson St., New York, N. Y.
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
General Winding Co., 420 West 45th St., New York, N. Y.
Girard-Hopkins, 1000 40th Ave., Oakland 1, Cal.
Halldorson Company, The, 4500 Ravenswood Ave., Chicago 28, Ill.
Industrial Condenser Corp., 3243 North California Ave., Chicago 18, Ill.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kenyon Transformer Co., 840 Barry St., New York 59, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Measurements Corp., Boonton, N. J.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Miller Co., J. W., 5917 S. Main St., Los Angeles, Calif.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Potter Co., 1950 Sheridan Rd., North Chicago, Ill.
Presto Recording Corp., 242 West 55th St., New York, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Solar Mfg. Corp., 285 Madison Ave., New York 17, N. Y.
Sprague Electric Co., 189 Beaver St., North Adams, Mass.
Technical Appliance Corp., 516 W. 34th St., New York 1, N. Y.
U. S. Television Mfg. Corp., 106 Seventh Ave., New York 11, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Whisk Laboratories, 87 Maiden Lane, New York 7, N. Y.

Finders, Direction

see Radio Compass Receivers

Finishes

INSULATING ENAMELS

Alden Products Co., 117 North Main St., Brockton 64, Mass.
Bakelite Corp., 30 E. 42nd St., New York 17, N. Y.
Day & Co., James B., 1872 Clybourn Ave., Chicago 14, Ill.
Dolph Co., John C., 1060 Broad St., Newark, N. J.
Du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Electric Service Manufacturing Co., 17th & Cambria Sts., Philadelphia 32, Pa.
Franklin Paint & Varnish Co., Benjamin, 4820 Langdon St., Philadelphia 24, Pa.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Schenectady 5, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
International Products Corp., Baltimore 18, Md.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Lilly Varnish Co., 670 S. California St., Indianapolis, Ind.
Lowe Bros. Co., 436 E. Third St., Dayton, Ohio
Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.
Murphy Finishes Corp., 224 McWhorter St., Newark 1, N. J.
New Wrinkle, Inc., 314 W. First St., Dayton 2, Ohio
Pratt & Lambert, Inc., 75 Tonawanda St., Buffalo 17, N. Y.
Roxalin Flexible Finishes, Inc., 800 Magnolia Ave., Elizabeth, F, N. J.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Standard Varnish Works, 2600 Richmond Terrace, Staten Island 3, N. Y.
Watson-Standard Co., 225 Galveston St., Pittsburgh, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Zapon Div., Atlas Powder Co., Ludlow St., Stamford, Conn.

INSULATING VARNISH

Aluminum Finishing Corp., 1119 E. 22nd St., Indianapolis, Ind.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Products Mfg. Co., 8127 Oleander St., New Orleans, La.
Arco Co., 7301 Bessemer Ave., Cleveland, 4, Ohio
B & C Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Bakelite Corp., 30 E. 42d St., New York 17, N. Y.
Communication Parts, 1101 N. Paulina St., Chicago 22, Ill.
Day & Co., James B., 1872 Clybourn Ave., Chicago 14, Ill.
Dolph Co., John C., 1060 Broad St., Newark, N. J.
Dow Corning Corp., Box 592, Midland, Mich.
Du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Durez Plastics & Chemicals, Inc., 1922 Walck Road, North Tonawanda, N. Y.
Electric Service Manufacturing Co., 17th & Cambria Sts., Philadelphia 32, Pa.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Pittsfield, Mass.
George Co., P. D., 5200 N. Second St., St. Louis, Mo.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Haynes Laboratories, Inc., C. W., 61 Chandler St., Springfield, Mass.
Hilo Varnish Corp., 42 Stewart Ave., Brooklyn, N. Y.
Insl-X Co., Inc., 857 Meeker Ave., Brooklyn, N. Y.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Jones-Dabney Co., Smith & Proback Sts., Louisville, Ky.
Lastik Products Co., Keenan Bldg., Pittsburgh, Pa.
Lilly Varnish Co., 670 S. California St., Indianapolis, Ind.
Lowe Brothers Co., 436 E. Third St., Dayton, Ohio
Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.
Makalot Corp., 262 Washington St., Boston, Mass.
Marblette Corp., 37-21-30th St., Long Island City 1, N. Y.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
Murphy Finishes Corp., 224 McWhorter St., Newark 1, N. J.
New Wrinkle, Inc., 314 W. First St., Dayton 2, Ohio
Pratt & Lambert, Inc., 75 Tonawanda St., Buffalo 17, N. Y.
Production Engrg. Corp., 666 Van Houten Ave., Clifton, N. J. (Service)
Robertson Chemical Co., 9808 Meech Ave., Cleveland, Ohio
Roxalin Flexible Finishes Inc., 800 Magnolia Ave., Elizabeth, F. N. J.
Schott Co. Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Standard Insulation Co., 74 Paterson Ave., East Rutherford, N. J.
Standard Varnish Works, 2600 Richmond Terrace, Staten Island 3, N. Y.
Sterling Varnish Co., Haysville, Pa.

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Watson-Standard Co., 225 Galveston St., Pittsburgh, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wipe-On Corp., 105 Hudson St., New York 13, N. Y.
Zapon Div., Atlas Powder Co., Ludlow St., Stamford, Conn.

LACQUER FINISHES

Alden Products Co., 117 North Main St., Brockton 64, Mass.
Ambroid Co., 305 Franklin St., Boston 10, Mass.
American Products Mfg. Co., 8127 Oleander St., New Orleans, La.
Arco Co., 7301 Bessemer Ave., Cleveland 4, Ohio
Bakelite Corp., 30 E. 42d St., New York 17, N. Y.
Communication Products Co., Inc., Route # 36 & Palmer Ave., Keansburg, N. J.
Day & Co., James B., 1872 Clybourn Ave., Chicago 14, Ill.
Dolph Co., John C., 1060 Broad St., Newark, N. J.
Du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Durez Plastics & Chemicals, Inc., 1922 Walck Road, North Tonawanda, N. Y.
Egyptian Lacquer Mfg. Co., 1270 Sixth Ave., New York, N. Y.
Franklin Paint & Varnish Co., Benjamin, 4820 Langdon St., Philadelphia 24, Pa.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Schenectady 5, N. Y.
Haynes Laboratories, Inc., C. W., 61 Chandler St., Springfield, Mass.
Hilo Varnish Corp., 42 Stewart Ave., Brooklyn, N. Y.
Howe & French, Inc., 99 Broad St., Boston 10, Mass.
Johnson & Co., S. C., Industrial Div., Racine, Wisc.
Jones-Dabney Co., Smith & Proback Sts., Louisville, Ky.
Lilly Varnish Co., 670 S. California St., Indianapolis, Ind.
Lowe Brothers Co., 436 E. Third St., Dayton, Ohio
Maas & Waldstein Co., 438 Riverside Ave., Newark, N. J.
Makalot Corp., 262 Washington St., Boston, Mass.
Marblette Corp., 37-21-30th St., Long Island City 1, N. Y.
Monsanto Chemical Co., Merrimac Div., Everett, Mass.
Murphy Finishes Corp., 224 McWhorter St., Newark 1, N. J.
New England Radiocrafters, 1156 Commonwealth Ave., Boston 34, Mass.
New Wrinkle, Inc., 314 W. First St., Dayton 2, Ohio
Pratt & Lambert, Inc., 75 Tonawanda St., Buffalo 17, N. Y.
Roxalin Flexible Finishes, Inc., 800 Magnolia Ave., Elizabeth F, N. J.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Standard Varnish Works, 2600 Richmond Terrace, Staten Island 3, N. Y.
Technical Products Co., 158 Madison Ave. at Third St., Memphis, Tenn.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Watson-Standard Co., 225 Galveston St., Pittsburgh, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Zapon Div., Atlas Powder Co., Ludlow St., Stamford, Conn.

Flock & Flocked Paper

Austin Co., O., 42 Greene St., New York, N. Y.
Auburn Mfg. Co., 110 Stack St., Middletown, Conn
Cellusuede Products, Inc., Rockford, Ill.
Flock Process Co., 53 West 21st St., New York 10, N. Y. Also, 3 Quincy St., Norwalk, Conn.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.

Flux, Solder

Allen Co., L. B., 6719 Bryn Mawr Ave., Chicago, Ill.
American Chemical Paint Co., Ambler, Pa.
American Solder & Flux Co., 2152 E. Norris St., Philadelphia 25, Pa.
Benson Co., Alex R., 4 E. Court St., Hudson, N. Y.
Burnley Battery & Mfg. Co., Clay St., North East, Pa.
Day & Co., James B., 1872 Clybourn Ave., Chicago, Ill.
Dunton Co., M. W., 670 Eddy St., Providence, R. I.
DuPont de Nemours & Co., E. I., Grasselli Chemicals Dept., Wilmington, Del.
Farrelloy Co., 1245 N. 26th St., Philadelphia, Pa.
Garden City Laboratory, 2744 W. 37th Pl., Chicago, Ill.
Geko Chemical Co., 143-05 Franconia Ave., Flushing, N. Y.
General Electric Co., Bridgeport, Conn.
Glaser Lead Co., Inc., 31 Wyckoff Ave., Brooklyn, N. Y.
Handy & Harman, 82 Fulton St., New York 7, N. Y.
Hercules Chemical Co., 332 Canal St., New York, N. Y.
Johnson Co., Lloyd S., 2241 Indiana Ave., Chicago, Ill.
Johnson Mfg. Co., 729 W. Washington Blvd., Chicago, Ill.
Jordan Co., 51st & S. Merrimac, Chicago 38, Ill.
Kester Solder Co., 4212 Wrightwood Ave., Chicago, Ill.
Lukens Metal Co., Thomas F., 3000 E. Hedley St., Philadelphia 37, Pa.
McGill Mfg. Co., Box 670, Valparaiso, Ind.
Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.
Mitchell-Rand Insulation Co., 51 Murray St., New York 7, N. Y.
Ogden Chemical Laboratories, 324 E. Third St., Cincinnati, Ohio
Ohio Carbon Co., 12508 Berea Rd., Cleveland, Ohio
Paragon Insulating Co., 5716 Euclid Ave., Cleveland, Ohio
Pfanstiehl Chemical Co., 104 Lake View Ave., Waukegan, Ill.
Rodale Mfg. Co., 6th & Minor Sts., Emaus, Pa.
Rotax Mfg. Co., 24 Bathgate Place, Newark 7, N. J.
Ruby Chemical Co., 68 McDowell St., Columbus, Ohio
Special Chemicals Co., 30 Irving Place, New York, N. Y.
Weaver Specialty Co., 6344 Aurelia St., Pittsburgh, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Forks

ELECTRICALLY DRIVEN TUNING FORKS

American Time Products, Inc., 580 Fifth Ave., New York 19, N. Y.
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Central Scientific Co., 1700 Irving Park Blvd., Chicago 13, Ill.
Chicago Apparatus Co., 1735 N. Ashland Ave., Chicago, Ill.
Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wisc.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Riverbank Laboratories, Geneva, Ill.
Stoelting Co., C. H., 424 N. Homan Ave., Chicago, Ill.
Stokes Rubber Co., Jos., Taylor & Webster Sts., Trenton, N. J.
Times Telephoto Equipment, Inc., 229 West 43rd St., New York, N. Y.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.

Forms

COIL FORMS

Accurate Spring Mfg. Co., 3811 W. Lake St., Chicago, Ill.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Lava Corp., Kruesi Bldg., Chattanooga 5, Tenn.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
Auburn Mfg. Co., 110 Stack St., Middletown, Conn.
Automatic Mfg. Co., 900 Passaic Ave., E. Newark, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bud Radio Inc., 2118 E. 55th St., Cleveland 3, Ohio
Centralab, Div. of Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Corning Glass Works, Corning, N. Y.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Crowley & Co., Inc., Henry L., 1 Central Ave., West Orange, N. J.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Electrical Insulation Co., Inc., 12 Vestry St., New York, N. Y.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Essex Electronics, 1060 Broad St., Newark 2, N. J.
General Ceramics & Steatite Corp., Keasbey, N. J.
General Winding Co., 420 West 45th St., New York, N. Y.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Hammarlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.
Hawley Products Co., St. Charles, Ill.
Haydu Bros., Mt. Bethel Rd., Plainfield, N. J.
Insulator Tube Co., Inc., 26 Cottage St., P. O. Box 1, Poughkeepsie, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Isolantite, Inc., 343 Cortlandt St., Belleville 9, N. J.
Johnson Co., E. F., Waseca, Minn.
Lenoxite Div. Lenox, Inc., 65 Prince St., Trenton, N. J.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Munsell & Co., Eugene, 200 Varick St., New York, N. Y.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Mykroy, Inc., 1917 N. Springfield Ave., Chicago 47, Ill.
National Co., 61 Sherman St., Malden, 48, Mass.
National Fabricated Products, 2650 Belden Ave., Chicago 47, Ill.
National Tile Co., 1200 East 26th St., Anderson, Ind.
National Vulcanized Fibre Co., Maryland Ave., Wilmington, Del.
New England Radiocrafters, 1156 Commonwealth Ave., Boston 34, Mass.
Northern Industrial Chemical Co., 11 Elkins St., So. Boston, Mass.
Pacific Clay Products Co., 306 West Avenue 26, Los Angeles 31, Calif.
Parker Engineering Prods. Co., 16 West 22nd St., New York 10, N. Y.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Plastic Manufacturers, Inc., Stamford, Conn.
Plax Corp., 133 Walnut St., Hartford 5, Conn.
Precision Paper Tube Co., 2033 W. Charleston St., Chicago 47, Ill.
Saxonburg Potteries, Saxonburg, Pa.
Small Motors, Inc., 1322 Elton Ave., Chicago 22, Ill.
Spaulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y.
Speer Resistor Corp., St. Marys, Pa.
Stokes Rubber Co., Jos., Taylor & Webster Sts., Trenton, N. J.
Taylor Fibre Co., Norristown, Pa.
Thomas & Sons Co., R., Lisbon, Ohio
Ucinite Corp., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Victory Manufacturing Co., 1722 W. Arcade Place, Chicago 12, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.

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ELECTRONIC and ALLIED PRODUCTS

Fuses

Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kans.
Automatic Electric Co., 1033 West Van Buren St., Chicago 7, Ill.
Bussmann Mfg. Co., University at Jefferson, St. Louis 7, Mo.
Chase-Shawmut Co., Newburyport, Mass.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Eagle Electric Mfg. Co., Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Foote Pierson & Co. Inc., 75 Hudson St., Newark 4, N. J.
General Electric Co., Bridgeport, Conn.
Littelfuse, Inc., 4755 Ravenswood Ave., Chicago, Ill.
Monarch Fuse Co., Ltd., Jamestown, N. Y.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Pierce Renewable Fuses Inc., 211 Hertel Ave., Buffalo 7, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

Galvanometers

See Meters

Gases

GASES, RARE

Air Reduction Sales Co., 60 East 42nd St., New York, N. Y.
American Gas & Chemical Co., 360 Warren St., Harrison, N. J.
Giannini & Co., Inc., G. M., 161 California St., Pasadena, Calif.
Linde Air Products Co., 30 E. 42nd St., New York 17, N. Y.

Gauges, Strain

American Instrument Company, Silver Springs, Md.
Baldwin-Locomotive Works, Eddystone, Pa.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Consolidated Engineering Corp., 595 E. Colorado St., Pasadena 1, California
Foxboro Co., Foxboro, Mass.
General Electric Co., Schenectady 5, N. Y.
Giannini & Co., Inc., C. M., 161 E. California St., Pasadena, Calif.
Hathaway Instrument Company, 1315 S. Clarkson St., Denver 10, Colorado
Metzger & Son, F. F., 2600 North Sixth St., Philadelphia 33, Pa.
Olsen Testing Machine Company, Philadelphia, Pa.
Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford, Conn.
Saxl Instrument Company, 38-40 James St., East Providence 14, R. I.
Starrett Company, L. S., 165 Crescent St., Athol, Mass.
Waugh Labs, Div. of Waugh Equipment Co., 420 Lexington Ave., New York, 17, N. Y.

Gears, Precision

Ace Mfg. Corp., 1255 E. Erie Ave., Philadelphia, Pa.
Beaver Gear Works Inc., Rockford, Ill.
Gear Specialties, 2635 W. Medill Ave., Chicago 47, Ill.
Gray Mfg. Co., 16-30 Arbor St., Hartford, Conn.
Lear, Incorporated, Piqua, Ohio
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Penn Fibre & Specialty Co., 2030 E. Westmoreland St., Philadelphia 34, Pa.
Perkins Machine & Gear Co., 130 Circuit Ave., Springfield, Mass.
Pratt & Whitney Div., Niles-Bement-Pond Co., West Hartford 1, Conn.
Quaker City Gear Works, 1910-32 N. Front St., Philadelphia, Pa.
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago 39, Ill.
Teleoptic Co., 1241 Mound Ave., Racine, Wisc.

Generators

DYNAMOTORS, ROTARY CONVERTERS

Air-Way Electric Appliance Corp., 2101 Auburn Ave., Toledo, Ohio
Alliance Mfg. Co., Lake Park Blvd., Alliance, Ohio
Allis Co., Louis, 427 E. Stewart St., Milwaukee 7, Wisc.
Allis Chalmers Mfg. Co., Milwaukee 1, Wisc.
Anco Products Corp., Paterson, N. J.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, North Hollywood, Calif.
Bogue Electric Co., Paterson, N. J.
Branston Electric Mfg. Co., 61-65 Gill Place, Buffalo 13, N. Y.
Burke Electric Co., 12th & Cranberry Sts., Erie, Pa.
Carson Machine & Supply Co., Box 4547, Oklahoma City 9, Okla.
Carter Motor Co., 1606 Milwaukee Ave., Chicago 47, Ill.
Caterpillar Tractor Co., Peoria 8, Ill.
Century Electric Co., 1806 Pine St., St. Louis 3, Mo.
Columbia Electric Mfg. Co., 4519 Hamilton Ave., N. E., Cleveland 14, Ohio
Communications Equipment Corp., 134 W. Colorado St., Pasadena 1, Calif.
Continental Electric Co., Inc., 325 Ferry St., Newark 5, N. J.
Crocker-Wheeler Elec. Mfg. Co., Div. of Joshua Hendy Iron Works, Ampere, N. J.
Diehl Mfg. Co., Finderne Plant, Somerville, N. J.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Eicor, Inc., 1501 W. Congress St., Chicago 7, Ill.
Electric Indicator Co., 21 Parker Ave., Stamford, Conn.
Electric Products Co., 1725 Clarkstone Road, Cleveland 12, Ohio
Electric Specialty Co., 211 South St., Stamford, Conn.
Electrical Engrg. & Mfg. Corp., 4606 W. Jefferson Blvd., Los Angeles 16, Calif.
Electrolux Corp., Old Greenwich, Conn.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Eureka Vacuum Cleaner Co., Detroit, Michigan
Fidelity Electric Co., 332 No. Arch St., Lancaster, Pa.
Fisher Research Laboratory, 1961 University Ave., Palo Alto, Calif.
General Electric Co., Schenectady 5, N. Y.
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wisc.
Holtzer-Cabot, Signal Div., 400 Stuart St., Boston 17, Mass.
Homelite Corp., Port Chester, N. Y.
Imperial Electric Co., 84 Ira Ave., Akron 1, Ohio
Janette Mfg. Co., 556 W Monroe St., Chicago 40, Ill.
Kato Engineering Co., 530 N. Front St., Mankato, Minn.
L. A. B. Corp., Summit, N. J.
Lear, Incorporated, Piqua, Ohio
Leland Electric Co., 1501 Webster St., Dayton, Ohio
Master Electric Co., 126 Davis Ave., Dayton, Ohio
Midco Mfg. & Distr. Co., Sheboygan, Wis.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
Onan & Sons, D. W., 3264 Royalston Ave., Minneapolis 5, Minn.
Penn Boiler & Burner Mfg. Corp., Fruitville Road, Lancaster, Pa.
Pioneer Gen-E-Motor Corp., 5841 W. Dickens Ave., Chicago 39, Ill.
Quality Electric Co., Ltd., 1235 East Olympic Bldg., Los Angeles 21, Calif.
Redmond Co. Inc., Monroe St., Owosso, Mich.
Reliance Electric & Engrg. Co., Ivanhoe Rd., Cleveland 10, Ohio
Robbins & Myers, 1345 Lagonda Ave., Springfield, Ohio
Russell Electric Co., 364 W. Huron St., Chicago 10, Ill.
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Sheridan Electronics Corp., 2850 S. Michigan Ave., Chicago, Ill.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Stockwell Transformer Corp., 569 S. Main St., Akron, Ohio
Trav-Ler Karenola Radio & Television Corp., 571 W. Jackson Blvd., Chicago, Ill.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago 47, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wincharger Corp., 7th & Division, Sioux City, Iowa
Wyse Laboratories, 211 S. Ludlow St., Dayton, Ohio

GAS AND HAND-DRIVEN GENERATORS

Burke Electric Co., 12 & Cranberry Sts., Erie, Pa.
Carter Motor Co., 1606 Milwaukee Ave., Chicago 47, Ill.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Continental Electric Co., Inc., 325 Ferry St., Newark 5, N. J.
Delco Appliance Div., General Motors Corp., 391 Lyell Ave., Rochester, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electric Specialty Co., 211 South St., Stamford, Conn.
Electrical Engrg. & Mfg. Corp., 4606 W. Jefferson Blvd., Los Angeles 16, Calif.
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
General Electric Co., Schenectady 5, N. Y.
General Television & Radio Corp., 2701 N. Lehman Ct., Chicago 14, Ill.
Homelite Corp., Port Chester, N. Y.
Imperial Electric Co., 84 Ira Ave., Akron 1, Ohio
Kato Engineering Co., 530 N. Front St., Mankato, Minn.
Midco Mfg. & Distributing Co., S. 13th & Kentucky Ave., Sheboygan, Wis.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
Onan & Sons, D. W., 3264 Royalston Ave., Minneapolis 5, Minn.
Pioneer Gen-E-Motor Corp., 5841 W. Dickens Ave., Chicago 39, Ill.
Quality Electric Co., Ltd., 1235 Olympic Blvd., Los Angeles 21, Calif.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill.

SIGNAL GENERATORS

Airadio, Inc., Stamford, Conn.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago, Ill.
Bendix Aviation Corp., Marine Div., 1 Hanson Place, Brooklyn, N. Y.
Bendix Radio Div., Bendix Aviation Corp., Baltimore 4, Md.
Boonton Radio Corp., Boonton, N. J.
Carron Mfg. Co., 415 S. Aberdeen St., Chicago, Ill.
Clough-Brengle Co., 5501 N. Broadway, Chicago 22, Ill.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Dayco Radio Corp., 915 Valley St., Dayton 4, Ohio
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eastern Specialty Co., 3617 N. Eighth St., Philadelphia 40, Pa.
Electric Indicator Co., 21 Parker Ave., Stamford, Conn.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Fada Radio & Electric Co., Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Federal Mfg. & Engineering Corp., 199-217 Steuben St., Brooklyn, N. Y.
Ferris Instrument Co., 110-112 Cornelia St., Boonton, N. J.
Freed Radio Corp., 200 Hudson St., New York, N. Y.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.

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General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Grenby Mfg. Co., Plainville, Conn.
Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Cal.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Jackson Electrical Instrument Co., 6-18 S. Patterson Blvd., Dayton 1, Ohio
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lewyt Corp., 60 Broadway, Brooklyn, N. Y.
Madison Electrical Products Corp., Madison, N. J.
Measurements Corp., Boonton, N. J.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Monarch Mfg. Co., 2014 N. Major Ave., Chicago, Ill.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Packard Bell Co., 1115 So. Hope St., Los Angeles, Calif.
Philharmonic Radio Corp., 528 E. 72nd St., New York 21, N. Y.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Radex Corp. of America, 53 West Jackson Blvd., Chicago 4, Ill.
Radio City Products Co., 127 W. 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Design Co., 1353 Sterling Place, Brooklyn, N. Y.
Reiner Electronics Co., 152 West 25th St., New York, N. Y.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Cal.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Signal Electronic & Mfg. Co., 114 East 16th Street, New York 3, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Superior Instruments Co., 227 Fulton St., New York 7, N. Y.
Technical Devices Corp., Beaufort & Eagle Rock Aves., Roseland, N. J.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Triumph Mfg. Co., 913 W. Van Buren St., Chicago 7, Ill.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Westinghouse Electric Corp., East Pittsburgh, Pa.
White Research, 899 Boylston St., Boston, Mass.

SQUARE WAVE GENERATORS

American Radio Co., 611 E. Garfield Ave., Glendale, Calif.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Belmont Radio Corp., 521 W. Dickens Ave., Chicago, Ill.
Browning Labs., Inc., 750 Main St., Winchester, Mass.
DuMont Laboratories, Inc., Allen B., 2 Main Ave., Passaic, N. J.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Fada Radio & Electric Co., Inc., 30-20 Thomson Ave., Long Island City, N. Y.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Grenby Mfg. Co., Plainville, Conn.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Measurements Corp., Boonton, New Jersey
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Philharmonic Radio Corp., 528 E. 72nd St., New York 21, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Reiner Electronics Co., 152 West 25th St., New York, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Transmitter Equipment Mfg. Co. Inc., 345 Hudson St., New York 14, N. Y.
White Research, 899 Boylston St., Boston, Mass.

Geophysical Apparatus

Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Atlas Exploration Co., 1911 West Alabama, Houston 6, Texas
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Engineering Laboratories, Inc., 602 E. Fourth St., Tulsa 3, Okla.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Fisher Research Lab., 1961 University Ave., Palo Alto, Calif.
Geophysical Instrument Co., Key Blvd. & Nash St., Arlington, Va.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Heiland Research Corp., 130 East Fifth St., Denver 9, Colo.
Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago, Ill.
Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.
Miller Corp., Wm., 362 W. Colorado St., Pasadena, Calif.
Technical Products Co., 158 Madison Ave. at Third St., Memphis, Tenn.
Western Geophysical Co., 711 Edison Bldg., Los Angeles 11, Calif.
White Research, 899 Boylston St., Boston, Mass.

Getters

King Laboratories, Inc., 205 Oneida St., Syracuse 4, N. Y.
Kemet Laboratories Co., Inc., West 117th St. & Madison Ave., Cleveland 1, Ohio
Radio Corp. of America, RCA Victor Div., Harrison, N. J.

Glass Insulation

see Insulation, Glass

Glass—Metal Sealing

Corning Glass Works, Corning, N. Y.
Polan Industries, Huntington 19, West Va.

Glass Tubing

see Tubing, Glass

Graphite

COLLOIDAL GRAPHITE

Acheson Colloids Corp., Port Huron, Mich.
Asbury Graphite Mills, Asbury, N. J.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Grafo Colloids Corp., Sharon, Pa.

Harnesses

WIRE HARNESSES

Air Shields, Inc., Hatboro, Pa.
Aircraft-Marine Products, Inc., 1523 N. Fourth St., Harrisburg, Pa.
Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
Airplane & Marine Instruments, Inc., Clearfield, Pa.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
Alpha Wire Corp., 50 Howard St., New York, N. Y.
American Electric Cable Co., Holyoke, Mass.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
Ansonia Electrical Co., Ansonia, Conn.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Belden Mfg. Co., 4647 W. Van Buren St., Chicago 44, Ill.
Branston Electric Mfg. Co., 61-65 Gill Place, Buffalo 13, N. Y.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Columbia Wire & Supply Co., 4106 N. Pulaski Road, Chicago 41, Ill.
Concord Radio Corp., 901 W. Jackson Blvd., Chicago, Ill.
Crescent Co., Pawtucket, R. I.
Diamond Instrument Co., North Ave., Wakefield, Mass.
Eagle Electric Mfg. Co., 23-10 Bridge Plaza S., Long Island City, N. Y.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eastern Specialty Co., 3617 N. Eighth St., Philadelphia 40, Pa.
Eby, Inc., Hugh, H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Electric Auto-Lite Co., Toledo 1, Ohio
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Electronic Supply Co., 207 Main St., Worcester, Mass.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
General Motors Corp., Packard Electric Div., Warren, Ohio
Holyoke Wire & Cable Co., Holyoke, Mass.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
J. F. D. Mfg. Co., 4111 Fort Hamilton Pkwy., Brooklyn, N. Y.
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, L. I., N. Y.
Jefferson Travis Radio Mfg. Corp., 245 East 23rd St., New York 10, N. Y.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kraft & Kraft, Peekskill, New York
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Lenz Electric Mfg. Co., 1751 N. Western Avenue, Chicago 47, Ill.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Lewyt Corp., 60 Broadway, Brooklyn, N. Y.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meissner Mfg. Div., Maguire Industries Inc., Mt. Carmel, Ill.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
Packard Electric Div., General Motors Corp., Warren, Ohio
Paranite Wire & Cable Div., Essex Wire Corp., Fort Wayne 6, Ind.
Radiotechnic Laboratory, 1328 Sherman Ave., Evanston, Ill.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y. (test equipment)
Union Aircraft Products Corp., 380 Second Ave., New York, N. Y.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Wallace Mfg. Co., Wm. T., Chili & Madison Aves., Peru, Ind.
Whitney-Blake Co., Dixwell Ave., New Haven 4, Conn.
Whittaker Cable Corp., North Kansas City, Mo.
Wood Electric Co., Inc., C. D., 826 Broadway, New York 3, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

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ELECTRONIC and ALLIED PRODUCTS

Headphones

Automatic Electric Co., 1033 W. Van Buren St., Chicago 1, Ill.
Aviometer Corp., 370 West 35th St., New York 1, N. Y.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Cannon Co., C. F., Springwater, N. Y.
Connecticut Telephone & Electric Div. of Great American Industries, 70 Britannia St., Meriden, Conn.
Consolidated Radio Products Co., 350 W. Erie St., Chicago 10, Ill.
Eby Co., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Murdock Mfg. Co., William J., Chelsea, Mass.
Myers & Sons, E. A., Radioear Bldg., Mt. Lebanon, Pittsburgh, Pa.
National Scientific Products Co., 5013 N. Kedzie Ave., Chicago 25, Ill.
Permoflux Corp., 4900 W. Grand Ave., Chicago, Ill.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Presto Recording Corp., 242 West 55th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Speakers, Inc., 221 E. Cullerton St., Chicago, Ill.
Shure Brothers, 225 W. Huron St., Chicago, Ill.
Sonotone Corp., P. O. Box 200, Saw Mill Rd., Elmsford, N. Y.
Speak-O-Phone Recording & Equipment Co., 23 W. 60 St., New York, N. Y.
Telex Products Co., Telex Park, Minneapolis, Minn.
Telephonics Corp., 350 West 31st St., New York, N. Y.
Tibbetts Laboratories, Camden, Maine
Trimm, Inc., 1770 W Berteau Ave., Chicago 13, Ill.

Heads, Cutting

see Recorders—Sound

Heating, Electronic

Aero Communications, Inc., 231 Main St., Hempstead, Long Island, N. Y.
Ajax Electrothermic Corp., Ajax Park, Trenton, N. J.
Allis Chalmers Mfg. Co., Milwaukee 1, Wisc. (Dielectric & Induction)
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa. (Dielectric & Induction)
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago 39, Ill.
Budd Induction Heating, Inc., Detroit, Mich.
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc. (Dielectric)
Cyclonics Mfg. Co., Inc., 3906 Hudson Blvd., Union City, N. J.
DeForest Labs., Lee, 5106 Wilshire Blvd., Los Angeles, Calif.
Duramold Div. of Fairchild Engine & Airplane Co., Girts Rd., Jamestown, N. Y.
Ecco High Frequency Electric Corp., 7020 Hudson Blvd., North Bergen, N. J. (Induction)
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Supply Co., 207 Main St., Worcester, Mass.
Federal Electric Co., Inc., 8700 South State St., Chicago 19, Ill.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Fischer, Robert A., 1720 Hillcrest Ave., Glendale 2, Calif.
General Electric Co., Schenectady 5, N. Y. (Induction & Dielectric)
Girdler Corp., Thermex Div., 224 E. Broadway, Louisville 1, Ky. (Dielectric)
Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Hunt & Sons, G. C., 544 Hanover, Carlisle, Pa.
Illinois Tool Works, 2501 N. Keeler Ave., Chicago 39, Ill.
Induction Heating Corp., 389 Lafayette St., New York, N. Y. (Dielectric & Induction)
Intra-Therm Corp., Third & Keo Way, Des Moines 9, Iowa
Johnson Co., E. F., Waseca, Minn.
Kahle Engineering Co., 1307 Seventh St., North Bergen, N. J.
Lepel High Frequency Laboratories, 39 West 60th St., New York, N. Y. (Dielectric & Induction)
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif. (Dielectric & Induction)
Ohio Crankshaft Co., 3800 Harvard Ave., Cleveland 1, Ohio (Induction)
Radio Corp. of America, RCA Victor Div., Camden, N. J. (Dielectric & Induction)
Radio Craftsmen, 1341 S. Michigan Ave., Chicago 5, Ill.
Radio Receptor Co., 251 West 19th St., New York 11, N. Y. (Dielectric)
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass. (Dielectric & Induction)
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif.
Scientific Equipment Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J. (Dielectric & Induction)
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago 39, Ill. (Dielectric)
Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y. (Dielectric)
Universal X-Ray Products, Inc., 1800 N. Francisco Ave., Chicago 47, Ill. (Induction)
Westinghouse Electric Corp., Industrial Electronics & X-Ray Div., Baltimore 3, Md. (Dielectric & Induction)
Westinghouse Electric Corp., E. Pittsburgh, Pa.
Weltronic Co., 3080 E. Outer Drive, Detroit, Mich.

Holders

CRYSTAL HOLDERS

see Crystals

Horns

SPEAKER PROJECTOR HORNS

Altec Lansing Corp., 1680 North Vine St., Los Angeles 28, Calif.
Atlas Sound Corp., 1443 39th St., Brooklyn, N. Y.
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Electronic Sound Engineering Co., 109 N. Dearborn St., Chicago 2, Ill.
Cinaudagraph Speakers, Inc., 3911 S. Michigan Ave., Chicago, Ill.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Hawley Products Co., St. Charles, Ill.
Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago, Ill.
Langevin Co., Inc., 37 West 65th Street, New York, N. Y.
Lifetime Sound Equipment Co., 1101 Adams St., Toledo, Ohio
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
National Scientific Products Co., 5013 N. Kedzie Ave., Chicago 25, Ill.
Olesen Illuminating Co., Ltd., Otto, 1560 Vine St., Hollywood 28, Calif.
Operadio Mfg. Co., St. Charles, Ill.
Racon Electric Co., Inc., 52 E. 19th St., New York 3, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.
Rosen & Co., Raymond, 32nd & Walnut Sts., Philadelphia 4, Pa.
SOS Cinema Supply Co., 449 West 42nd Street, New York 18, N. Y.
Signal Engineering & Mfg. Co., 154 West 14th Street, New York, N. Y.
Simpson Mfg. Co., Inc., Mark, 188 W. Fourth St., New York, N. Y.
University Laboratories, 225 Varick St., New York, N. Y.
Utah Radio Products Co., 820 Orleans Street, Chicago, Ill.
Western Electric Co., Inc., 120 Broadway, New York, N. Y.

Indicators

CAPACITOR LEAKAGE INDICATORS

Amplifier Co. of America, 396 Broadway, New York, N. Y.
Cornell-Dubilier Electric Corp., 1000 Hamilton Blvd., South Plainfield, N. J.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
H-W Mfg. Co., 3124 Larga Ave., Los Angeles, Calif.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Industrial Instruments, Inc., 156 Culver Ave., Jersey City 5, N. J.
Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 1, Ohio
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.

POWER LEVEL INDICATORS and RECORDERS

Amplifier Co. of America, 396 Broadway, New York, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Boes Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
Daven Co., 191 Central Ave., Newark 4, N. J.
DeJur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Marion Electrical Instrument Co., Manchester, N. H.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Monarch Mfg. Co., 2014 N. Major Ave., Chicago, Ill.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

VOLUME INDICATORS

see Meters

Inductors

see Coils

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Insulation

see also Tubing, Finishes

ASBESTOS INSULATION

Carey Mfg. Co., Philip, Lockland, Cincinnati, Ohio
Johns-Manville, 20 East 40th St., New York, N. Y.
Keasbey & Mattison, Ambler, Pa.
Powhatan Mining Co., Baltimore 7, Md.

BEAD INSULATION

American Lava Corp., Kruesi Bldg., Chattanooga 5, Tenn.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
Centralab Div., Globe Union Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Corning Glass Works, Corning, N. Y.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
International Products Corp., Baltimore 18, Md.
Isolantite, Inc., 343 Cortlandt St., Belleville 9, N. J.
Johnson Co., E. F., Waseca, Minn.
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton, N. J.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Mykroy, Inc., 1917 N. Springfield Ave., Chicago 47, Ill.
National Tile Co., 1200 East 26th St., Anderson, Ind.
Ogush, Inc., William B., 33 W. 60th St., New York, N. Y.
Pacific Clay Products Co., 306 West Avenue 26, Los Angeles 31, Calif.
Plax Corp., 133 Walnut St., Hartford 5, Conn.
Printloid, Inc., 95 Mercer St., New York 12, N. Y.
Saxonburg Potteries, Saxonburg, Pa.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Steward Mfg. Co., D. M., E. 36th St., Chattanooga, Tenn.
Taylor Fibre Co., Norristown, Pa.

CERAMIC INSULATION

Akron Porcelain Co., Cory Ave., & Belt Line, Akron, Ohio
American Lava Corp., Kruesi Bldg., Chattanooga 5, Tenn.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Bud Radio Inc., 2118 East 55th St., Cleveland 3, Ohio
Centralab Div. of Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Cook Ceramic Mfg. Co., 501 Prospect St., Trenton 1, N. J.
Crowley & Co., Inc., Henry L., 1 Central Ave., West Orange, N. J.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Fleron & Son, Inc., M. M., 113 N. Broad St., Trenton, N. J.
General Ceramics & Steatite Corp., Keasbey, N. J.
General Electric Co., Schenectady 5, N. Y.
General Porcelain Co., 951 Pennsylvania Ave., Trenton, N. J.
Hartford Faience Co., 271 Hamilton St., Hartford, Conn.
Illinois Electric Porcelain Co., Macomb, Ill.
International Products Corp., Baltimore 18, Md.
Isolantite, Inc., 343 Cortlandt St., Belleville 9, N. J.
Johnson Co., E. F., Waseca, Minn.
Knox Porcelain Corp., 200 Mynderse Ave., Knoxville, Tenn.
Lapp Insulator Co., 31 Gilbert St., Le Roy, N. Y.
Lenoxite Div., Lenox, Inc., 65 Prince St., Trenton, N. J.
Louthan Mfg. Co., 2000 Harvey Ave., East Liverpool, Ohio
Metsch Refractories Co., East Liverpool, Ohio
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Mykroy, Inc., 1917 N. Springfield Ave., Chicago 47, Ill.
National Ceramic Co., 400 Southard St., Trenton 2, N. J.
National Tile Co., 1200 East 26th St., Anderson, Ind.
Ohio Brass Co., Mansfield, Ohio
Pacific Clay Products Co., 306 West Ave., 26, P. O. Box 145, Sta. A., Los Angeles 31, Calif.
Pass & Seymour Inc., Solvay Station, Syracuse, N. Y.
Pemco Corp., Plastics Div., 5601 Eastern Ave., Baltimore 24, Md.
Porcelain Insulator Corp., 447 E. Main St., Lima, N. Y.
Porcelain Products, Inc., 124 West Front St., Findlay, Ohio
Porcelier Mfg. Co., Greensburg, Pa.
Radio Corp. of America, Tube Div., RCA, Harrison, N. J.
Saxonburg Potteries, Saxonburg, Pa.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Square D Co., 6060 Rivard St., Detroit 11, Mich.
Star Porcelain Co., 61 Muirhead Ave., Trenton 9, N. J.
Steward Mfg. Co., D. M., East 36th St., Chattanooga, Tenn.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Thomas & Sons Co., R., Lisbon, Ohio
Union Electrical Porcelain Works, Van St., Trenton 5, N. J.
Universal Clay Products Co., 1505 E. First St., Sandusky, Ohio
Washington Porcelain Co., Washington, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wisconsin Porcelain Co., Sun Prairie, Wisc.

FABRIC INSULATION

Auburn Mfg. Co., 110 Stack St., Middletown, Conn.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Baer Co., N. S., 9 Montgomery St., Hillside, N. J.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Dobeckmun Co., 3300 Monroe Ave., Cleveland, Ohio
Du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Electric Service Manufacturing Co., 17th & Cambria Sts., Philadelphia 32, Pa.
Electro Technical Products, Inc., Nutley 10, N. J.
Endurette Corp. of America, Cliffwood, N. J.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
Greenhut Insulation Co., 31 West 21 St., New York, N. Y.
Holliston Mills, Inc., Norwood, Mass.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
McInerney Plastics Co., 655 Godfrey Ave., S. W., Grand Rapids 1, Mich.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
New Jersey Wood Finishing Co., Inc., Electrical Insulation Dept., Woodbridge, N. J.
Racon Electric Co., 52 East 19th St., New York 3, N. Y.
Saxonburg Potteries, Saxonburg, Pa.
Standard Insulation Co., 74 Paterson Ave., East Rutherford, N. J.
Taylor Fibre Co., Norristown, Pa.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
Varflex Corp., N. Jay St., Rome, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wright & Sons Co., Wm. E., West Warren, Mass.

FIBRE INSULATION

Acme Folding Box Co., Inc., 141 East 25th St., New York, N. Y.
American Felt Co., Glenville, Conn.
Auburn Mfg. Co., 110 Stack St., Middletown, Conn.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Baer Co., N. S., 9 Montgomery St., Hillside, N. J.
Bakelite Corp., Unit of Union Carbide & Carbon Corp., 30 East 42nd St., New York 17, N. Y.
Brandywine Fibre Products Co., 14th & Walnut Sts., Wilmington, Del.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Dobeckmun Co., 3300 Monroe Ave., Cleveland, Ohio
Electric Service Manufacturing Co., 17th & Cambria Sts., Philadelphia 32, Pa.
Felters Co., The, 210 South St., Boston, Mass.
Franklin Fibre-Lamitex Corp., 12th & French Sts., Wilmington, Del.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
Hawley Products, St. Charles, Ill.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Lamicoid Fabricators, 3600 W. Potomac Ave., Chicago, Ill.
McInerney Plastics Co., 655 Godfrey Ave., S. W., Grand Rapids 1, Mich.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
National Vulcanized Fibre Co., Maryland Ave., Wilmington, Del.
Penn Fibre & Specialty Co., 2030 E. Westmoreland St., Philadelphia 34, Pa.
Precision Fabricators, Inc., 120 N. Fitzhugh St., Rochester, N. Y.
Printloid, Inc., 95 Mercer St., New York 12, N. Y.
Rogers Paper Mfg. Co., Manchester, Conn.
Spaulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y.
Stevens Paper Mills, Inc., Windsor, Conn.
Taylor Fibre Co., Norristown, Pa.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
Varflex Corp., N. Jay St., Rome, N. Y.
West Virginia Pulp & Paper Co., 230 Park Ave., New York, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wilmington Fibre Specialty Co., P. O. Drawer 1028, Wilmington 99, Del.

GLASS & FIBERGLAS INSULATION

Aerolux Light Corp., 653-11th Ave., New York 19, N. Y.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Bentley, Harris Mfg. Co., Hector & Lime Sts., Conshohocken, Pa.
Brand & Co., William, 276 Fourth Ave., New York 10, N. Y.
Corning Glass Works, Corning, N. Y.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Electro Technical Products, Inc., Nutley 10, N. J.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
International Products Corp., Baltimore 18, Md.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Kilburn Glass Co., Inc., J. R., 22 S. Worcester St., Chartley, Mass.
Kopp Glass, Inc., 1 East 42nd St., New York 17, N. Y.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
New Jersey Wood Finishing Co., Inc., Electrical Insulation Dept., Woodbridge, N. J.
Owens-Corning Fiberglas Corp., 1860 Nicholas Bldg., Toledo 1, Ohio
Rome Cable Corp., 330 Ridge St., Rome, N. Y.

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ELECTRONIC and ALLIED PRODUCTS

paulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y.
perti, Inc., Norwood Station, Cincinnati 12, Ohio
tandard Insulation Co., 74 Paterson Ave., E. Rutherford, N. J.
arflex Corp., N. Jay St., Rome, N. Y.
Vestinghouse Electric Corp., East Pittsburgh, Pa.

GLASS BONDED MICA INSULATION

Brand & Co., William, 276 Fourth Avenue, New York 10, N. Y.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
General Electric Co., Schenectady 5, N. Y.
International Products Corp., Baltimore 18, Md.
Johnson Co., E. F., Waseca, Minn.
Macallen Co., 16 Macallen St., Boston, Mass.
Mica Insulator Co., 797 Broadway, Schenectady, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Mykroy, Inc., 1917 N. Springfield Ave., Chicago 47, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.

PAPER INSULATION

Acme Folding Box Co., Inc., 141 East 25th St., New York, N. Y.
Auburn Mfg. Co., 110 Stack St., Middletown, Conn.
Baer Co., N. S., 9 Montgomery St., Hillside, N. J.
Central Paper Co., Muskegon, Michigan
Continental-Diamond Fibre Co., 16 Chapel St. Newark, Del.
Cottrell Paper Co., 88 Purchase St., Fall River, Mass.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Dobeckmun Co., 3300 Monroe Ave., Cleveland, Ohio
Electric Service Manufacturing Co., 17th & Cambria Sts., Philadelphia 32, Pa.
Electro Technical Products, Inc., Nutley 10, N. J.
Endurette Corp. of America, Cliffwood, N. J.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Hartford City Paper Co., Hartford City, Indiana
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Lamicoid Fabricators, 3600 W. Potomac Ave., Chicago, Ill.
Manning Paper Co., Inc., John A., Troy, N. Y.
Mica Insulator Co., 797 Broadway, Schenectady, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
New Jersey Wood Finishing Co., Inc., Electrical Insulation Dept., Woodbridge, N. J.
Penn Fibre & Specialty Co., 2030 E. Westmoreland St., Philadelphia 34, Pa.
Precision Fabricators, Inc., 120 N. Fitzhugh St., Rochester, N. Y.
Riegel Paper Corp., 342 Madison Ave., New York 17, N. Y.
Rogers Paper Mfg. Co., Manchester, Conn.
Rome Cable Corp., 330 Ridge St., Rome, N. Y.
Schweitzer Paper Co., 142 Miller St., Newark, N. J.
Smith Paper Co., Inc., Lee, Mass.
Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N. Y.
Standard Insulation Co., 74 Paterson Ave., East Rutherford, N. J.
Stevens Paper Mills, Inc., Windsor, Conn.
Taylor Fibre Co., Norristown, Pa.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
West Virginia Pulp & Paper Co., 230 Park Ave., New York, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wilmington Fibre Specialty Co., P. O. Drawer 1028, Wilmington 99, Del.

PLASTIC INSULATION

Acadia Synthetic Products, Div. Western Felt Works, 4035 Ogden Ave., Chicago 23, Ill.
Accurate Molding Corp., 116 Nassau St., Brooklyn 1, N. Y.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
Aluminum Finishing Corp., 1119 E. 22nd St., Indianapolis, Ind.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Products Mfg. Co., 8127 Oleander St., New Orleans, La.
Anchor Plastics Co., 533-41 Canal St., New York 13, N. Y.
Ansonia Clock Co., Inc., 108 Lafayette St., New York 13, N. Y.
Atlas Products Corp., 30 Rockefeller Plaza, New York 20, N. Y.
Auburn Button Works, Inc., 48 Canoga St., Auburn, N. Y.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Baer Co., N. S., 9 Montgomery St., Hillside, N. J.
Bakelite Corp., Unit of Union Carbide & Carbon Corp., 30 East 42nd St., New York 17, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bastian Bros. Co., 1600 N. Clinton St., Rochester, N. Y.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Biwax Corp., 3445 Howard St., Skokie, Ill.
Brand & Co., William, 276 Fourth Ave., New York 10, N. Y.
Brandywine Fibre Products Co., 14th & Walnut Sts., Wilmington, Del.
Burndy Engrg. Co., Inc., 107 Bruckner Blvd., New York 54, N. Y.
Carter Products Co., 6921 Carnegie Ave., Cleveland, Ohio
Celanese Plastics Corp., 180 Madison Ave., New York 16, N. Y.
Cincinnati Molding Co., 2037 Florence Ave., Cincinnati 6, Ohio
Cochrane Chemical Co., 432 Danforth Ave., Jersey City, N. J.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Davis Plastics Co., Joseph, Arlington, N. J.
Dow Chemical Co., Midland, Mich.
Du Pont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Durez Plastics & Chemicals, Inc., 1922 Walck Rd., North Tonawanda, N. Y.
Eastman Kodak Co., Rochester 4, N. Y.
Electrical Insulation Co., Inc., 12 Vestry St., New York, N. Y.
Extruded Plastics, Inc., Norwalk, Conn.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Formica Insulation Co., 4662 Spring Grove Ave., Cincinnati, Ohio
Franklin Fibre-Lamitex Corp., 12th & French St., Wilmington, Del.
Garfield Mfg. Co., Garfield, N. J.
Gemloid Corp., 79-10 Albion Ave., Elmhurst, Long Island, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Plastics Dept., 1 Plastics Ave., Pittsfield, Mass.
Gering Products, Inc., 7th & Monroe Ave., Kenilworth, N. J.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Goodyear Tire & Rubber Co., Plastics & Chemical Div., 1144 E. Market St., Akron 16, Ohio
Hodgman Rubber Co., Framingham, Mass.
Hope Webbing Co., Providence, R. I.
Industrial Synthetics Corp., 60 Woolsey St., Irvington, N. J.
Insulating Tube Co., Inc., 26 Cottage St., P. O. Box 1, Poughkeepsie, N. Y.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
International Products Corp., Baltimore 18, Md.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Johnson Co., E. F., Waseca, Minn.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Kurz-Kasch Co., 1415 S. B'way, Dayton 1, Ohio
Makalot Corp., 262 Washington St., Boston, Mass.
McInerney Plastics Co., 655 Godfrey Ave., S. W., Grand Rapids 1, Mich.
Mica Insulator Co., 797 Broadway, Schenectady, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Micarta Fabricators, Inc., 5324 Ravenswood Ave., Chicago 40, Ill.
Mills Corp., Elmer E., 812 W. Van Buren St., Chicago, Ill.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
Monsanto Chemical Co., Plastics Div., Springfield 2, Mass.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Mykroy, Inc., 1917 N. Springfield Ave., Chicago 47, Ill.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
National Vulcanized Fibre Co., Maryland Ave., Wilmington, Del.
New Jersey Wood Finishing Co., Inc., Electrical Insulation Dept., Woodbridge, N. J.
Northwest Plastics, Inc., 2333 University Ave., St. Paul 4, Minn.
Oris Mfg. Co., Inc., Thomaston, Conn.
Panelyte Div., St. Regis Paper Co., 230 Park Ave., New York, N. Y.
Parisian Novelty Co., 3510 S. Western Ave., Chicago 9, Ill.
Penn Fibre & Specialty Co., 2030 E. Westmoreland St., Philadelphia 34, Pa.
Plastic Fabricators Co., 440 Sansome St., San Francisco 11, Calif.
Plax Corp., 133 Walnut St., Hartford, 5, Conn.
Precision Fabricators, Inc., 120 N. Fitzhugh St., Rochester, N. Y.
Printloid, Inc., 95 Mercer St., New York 12, N. Y.
Resistoflex Corp., Belleville 9, N. J.
Respro, Inc., Wellington Ave., Cranston, N. J.
Richardson Co., Melrose Park, Ill.
Rogers Paper Mfg. Co., Manchester, Conn.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N. Y.
Standard Products Co., 505 Boulevard Bldg., Detroit 2, Mich.
Surprenant Electrical Insulation Co., 84 Purchase St., Boston 10, Mass.
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Technical Products Co., 158 Madison Ave., at Third St., Memphis, Tenn.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Varflex Corp., N. Jay St., Rome, N. Y.
Waterbury Button Co., 835 S. Main St., Waterbury, Conn.
Werner Co., Inc., R. D., 295 Fifth Ave., New York 16, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Whitney-Blake Co., Dixwell Ave., New Haven, Conn.
Wilmington Fibre Specialty Co., P. O. Drawer 1028, Wilmington 99, Del.

STEATITE INSULATION

American Lava Corp., Kruesi Bldg., Chattanooga 5, Tenn.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Bud Radio, Inc., 2118 East 55th St., Cleveland 3, Ohio
Centralab Div. of Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Cook Ceramic Mfg. Co., 501 Prospect St., Trenton 1, N. J.
Crowley & Co., Inc., Henry, 1 Central Ave., West Orange, N. J.
General Ceramics and Steatite Corp., Keasbey, N. J.
General Electric Co., Schenectady 5, N. Y.
Isolantite, Inc., 343 Cortlandt St., Belleville 9, N. J.
Johnson Co., E. F., Waseca, Minn.
Lapp Insulator Co., 31 Gilbert St., LeRoy, N. Y.
Lenoxite Div., Lenox, Inc., 65 Prince St., Trenton, N. J.
Louthan Mfg. Co., 2000 Harvey Ave., E. Liverpool, Ohio
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.

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National Ceramic Co., 400 Southard St., Trenton 2, N. J.
National Tile Co., 1200 East 26th St., Anderson, Indiana
Ohio Brass Co., Mansfield, Ohio
Pacific Clay Products Co., 306 West Ave., Los Angeles 31, Calif.
Pass & Seymour, Inc., Solvay Station, Syracuse, N. Y.
Radio Corp. of America, Tube Div., RCA, Harrison, N. J.
Saxonburg Potteries, Saxonburg, Pa.
Star Porcelain Co., Trenton 9, N. J.
Steward Mfg. Co., D. M., Chattanooga, Tenn.
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Wisconsin Porcelain Co., Sun Prairies, Wisc.

Insulators

Acme Folding Box Co., Inc., 141 East 25th St., New York, N. Y.
Akron Porcelain Co., Cory Ave., & Belt Line, Akron, Ohio
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Lava Corp., Kruesi Bldg., Chattanooga 5, Tenn.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
Arens Controls, Inc., 2253 S. Halsted St., Chicago 8, Ill.
Armstrong Cork Co., Lancaster, Pa.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Cardy-Lundmark Co., 1801 W. Byron St., Chicago 13, Ill.
Centralab Div., Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Fleron & Son, Inc., M. M., 113 N. Broad St., Trenton, N. J.
General Electric Co., Schenectady 5, N. Y.
Hanovia Chemical & Mfg. Co., 233 New Jersey & R. R. St., Newark, N. J.
Insulation Mfg. Co., 11 New York Ave., Brooklyn, N. Y.
International Products Corp., Baltimore 18, Md.
Isolantite, Inc., 343 Cortlandt St., Belleville 9, N. J.
Johnson Co., E. F., Waseca, Minn.
Lapp Insulator Co., 31 Gilbert St., LeRoy, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Mykroy, Inc., 1917 N. Springfield Ave., Chicago 47, Ill.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
National Tile Co., 1200 East 26th St., Anderson, Ind.
Pacific Clay Products Co., 306 West Ave., 26, Los Angeles 31, Calif.
Parisian Novelty Co., 3510 S. Western Ave., Chicago 9, Ill.
Philadelphia Mica Corp., 3515 N. 10 St., Philadelphia 40, Pa.
Porcelain Products, Inc., 124 W. Front St., Findlay, Ohio
Premax Products Div., Chisholm Ryder Co., College & Highland Aves., Niagara Falls 2, N. Y.
Radio Corp. of America, Tube Div., RCA, Harrison, N. J.
Saxonburg Potteries, Saxonburg, Pa.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Stupakoff Ceramic & Mfg. Co., Latrobe, Pa.
Taylor Fibre Co., Norristown, Pa.
Thomas & Sons Co., R., Lisbon, Ohio
Union Electrical Porcelain Works, Van St., Trenton 5, N. J.
Victor Insulators, Inc., Victor, N. Y.
Waterbury Button Co., 835 S. Main St., Waterbury, Conn.
Westinghouse Electric Corp., East Pittsburgh, Pa.

INSULATORS, TRANSMITTING ANTENNA

Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kans.
American Lava Corp., Kruesi Bldg., Chattanooga 5, Tenn.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Centralab Div. of Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Johnson Co., E. F., Waseca, Minn.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Premax Products Div., Chisholm Ryder Co., College & Highland Ave., Niagara Falls, N. Y.

Insulators, Vibration

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Intercommunicators

American Radio Co., 611 E. Garfield Ave., Glendale, Calif.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Ansley Radio Corp., 21-10 49th Ave., Long Island City, N. Y.
Autocrat Radio Co., 3855 N. Hamilton Ave., Chicago, Ill.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Banks Mfg. Co., 1105 W. Lawrence Ave., Chicago 40, Ill.
Bell Sound Systems, Inc., 1183 Essex Ave., Columbus, Ohio
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago 39, Ill.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, North Hollywood, Calif.
Bogen Co., David, 663 Broadway, New York 12, N. Y.
Bond Products Co., 13139 Hamilton Ave., Detroit, Mich.
California Telephone & Elec. Co., 6075 W. Pico Blvd., Los Angeles 35, Calif.
Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Dalmo Victor, San Carlos, Calif.
De Wald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Eastern Amplifier Corp., 794 East 140th St., Bronx, New York 54, N. Y.
Eckstein Radio & Television Co., 918 La Salle Ave., Minneapolis 2, Minn.
Electronic Sound Engineering Co., 109 N. Dearborn St., Chicago 2, Ill.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Executone, Inc., 415 Lexington Ave., New York 17, N. Y.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
General Electronics, Inc., 101 Hazel St., Paterson, N. J.
Globe Phone Mfg. Corp., 2 Linden St., Reading, Mass.
Godfrey Mfg. Co., 171 S. 2nd St., Milwaukee 4, Wisc.
Halstead Traffic Communications Corp., 155 E. 44th St., New York, N. Y.
Industrial Sound Products Co., 3597 Mission St., San Francisco, Calif.
Kegron Mfg. Co., Inc., 18 West 20th St., New York 11, N. Y.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Lake Mfg. Co., 2323 Chestnut St., Oakland 7, Calif.
Magnavox Co., The, 2131 Bueter Rd., Fort Wayne 4, Ind.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Minerva Corp. of America, 238 William St., New York 7, N. Y.
National Intercommunicating Systems, 2434 Montrose Ave., Chicago 18, Ill.
Newcomb Audio Products Co., 2815 S. Hill St., Los Angeles 18, Calif.
Operadio Mfg. Co., St. Charles, Ill.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Philco Corp., Philadelphia 34, Pa.
Powers Electronic & Communication Co., Glencove, L. I., N. Y.
Racon Electric Co., 52 East 19th St., New York 3, N. Y.
Radio Corp., RCA Victor Div., of America, Camden, N. J.
Radio Laboratories, Inc., 2701 California Ave., Seattle 6, Wash.
Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.
Regal Electronics Corp., 20 West 20th St., New York, N. Y.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif.
Schulmerich Electronics Co., Sellersville, Pa.
Select-O-Phone Co., 1012 Eddy St., Providence, R. I.
Setchell Carlson, Inc., 2233 University Ave., St. Paul 4, Minn.
Simpson Mfg. Co., Inc., Mark, 188 West Fourth St., New York, N. Y.
Talk-A-Phone Mfg. Co., 1512 S. Pulaski Road, Chicago 23, Ill.
Taybern Equipment Co., 120 Greenwich St., New York 6, N. Y.
Tech-Master Products Co., 12 Prince St., New York, N. Y.
TelAutograph Corp., 16 West 61st St., New York 23, N. Y.
Telemotor Corp., 260 Fifth Ave., New York, N. Y.
Telephonics Corp., 350 West 31st St., New York 1, N. Y.
Templetone Radio Mfg. Corp., New London, Conn.
Trebor Radio Co., Pasadena, Calif.
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill.
Watterson Radio Mfg. Co., P. O. Box 54, Dallas 1, Texas
Webster Electric Co., 1900 Clark St., Racine, Wisc.
Western Sound & Electric Laboratories, 3512 W. St. Paul Ave., Milwaukee, Wisc.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

Inverters

Air-Way Electric Appliance Corp., 2101 Auburn Ave., Toledo, Ohio
Allis-Chalmers Mfg. Co., Milwaukee 1, Wisc.
American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
Anco Products Corp., Paterson, N. J.
Apex Electric Mfg. Co., 1070 E. 152nd St., Cleveland, Ohio
Carter Motor Co., 1606 Milwaukee Ave., Chicago 47, Ill.
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
Eclipse-Pioneer Div., Bendix Corp., Teterboro, N. J.
Elcor, Inc., 1501 W. Congress St., Chicago 7, Ill.
Electric Specialty Co., Stamford, Conn.
Electrical Engineering & Mfg. Co., 4666 W. Jefferson Blvd., Los Angeles, Calif.
Electrolux Corp., Old Greenwich, Conn.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Laboratories, Inc., Indianapolis, Ind.
General Electric Co., Schenectady 5, N. Y.
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wisc.
Holtzer-Cabot, Signal Division, 400 Stuart St., Boston 17, Mass.
International Transformer Co., 396 Broadway, New York, N. Y.
Janette Mfg. Co., 556 W. Monroe St., Chicago 40, Ill.
Leland Electric Co., 1501 Webster St., Dayton, Ohio
Linde Air Products Co., 30 East 42nd St., New York 17, N. Y.
Master Electric Co., 126 Davis Avenue, Dayton, Ohio
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Pioneer Gen-E-Motor Co., 5841 Dickens Avenue, Chicago 39, Ill.
Quality Electric Co., Ltd., 1235 E. Olympic Blvd., Los Angeles 21, Calif.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Russell Electric Co., 364 W. Huron St., Chicago 10, Ill.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Union Switch & Signal Co., Swissvale, Pa.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago 47, Ill.

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ELECTRONIC and ALLIED PRODUCTS

Westinghouse Elec. Corp., Lima, Ohio
Wincharger Corp., 7th & Division, Sioux City, Iowa

Irons

ELECTRIC SOLDERING IRONS

Acme Electric Heating Co., 1217 Washington St., Boston, Mass.
American Electrical Heater Co., 6110 Cass Ave., Detroit 2, Mich.
Baker-Phillips Co., 3017 Lyndale Ave. S., Minneapolis 8, Minn.
Brach Mfg. Corp., L. S., 55 Dickerson St., Newark, N. J.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Cole Radio Works, 86 Westville Ave., Caldwell, N. J.
Drake Electric Works, 3656 Lincoln Ave., Chicago 13, Ill.
Eagle Electric Mfg. Co., Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Electric Soldering Iron Co., Deep River, Conn.
General Electric Co., Schenectady 5, N. Y.
Glaser Lead Co., Inc., 31 Wyckoff Ave., Brooklyn, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Hexacon Electric Company, 161 W. Clay Ave., Roselle Park, N. J.
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Jackson Electro Corp., 124 Bleeker St., New York, N. Y.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kelnor Mfg. Co., Central Tower Bldg., San Francisco, Calif.
Lenk Mfg. Co., Newton Lower Falls, Mass.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Sound Equipment Corp. of California, 3903 San Fernando Road, Glendale 4, Calif.
Stanley Works, New Britain, Conn.
Trent Co., Harold E., Leverington Ave. & Wilde St., Philadelphia 27, Pa.
Ungar Electric Tools, Inc., 615 Ducommun St., Los Angeles 54, Calif.
Vasco Electrical Mfg. Co., 4116 Avalon Blvd., Los Angeles 11, Calif.
Vulcan Electric Co., 88 Holten St., Danvers, Mass.
Weller Mfg. Co., 516 Northampton St., Easton, Pa.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

Jacks

see also Plugs

A.B.C. Products, Inc., 11952 Montana Ave., W. Los Angeles, Calif.
Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
Amalgamated Radio & Television Corp., 476 Broadway, New York 13, N. Y.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway. S., Mt. Vernon, N. Y.
Audio Development Co., 2833 13th Ave., S., Minneapolis 7, Minn.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Automatic Metal Products Corp., 315 Berry St., Brooklyn, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bead Chain Mfg. Co., 110 Mt. Grove St., Bridgeport 5, Conn.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Connecticut Telephone & Elec. Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Eby, Inc., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Electronic Products Mfg. Corp., 7300 Huron River Drive, Dexter, Mich.
Federal Mfg. & Engrg. Corp., 199 Steuben St., Brooklyn, N. Y.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electronics Mfg. Co., 2225 S. Hoover St., Los Angeles 7, Calif.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Heinze Electric Co., Lowell, Mass.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2460 W. George St., Chicago 18, Ill.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Mossman, Inc., Donald P., 612 North Michigan Ave., Chicago 11, Ill.
National Electronic Mfg. Corp., 22-78 Steinway St., Long Island City 5, N. Y.
National Fabricated Products, 2650 Belden Ave., Chicago 47, Ill.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Presto Electric Co., 4511 New York Ave., Union City, N. J.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Telephonics Corp., 350 West 31st St., New York, N. Y.
Trav-Ler Karenola Radio & Television Corp., 571 W. Jackson Blvd., Chicago, Ill.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Wood Electric Co., Inc., C. D., 826 Broadway, New York 3, N. Y.

Keys and Coding Equipment

Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway. S., Mt. Vernon, N. Y.
Bud Radio, Inc., 2118 E. 55 St., Cleveland, 3, Ohio
Bunnell & Co., J. H., 215 Fulton St., New York, N. Y.
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Electro-Medical Laboratory, Inc., Hollis-ton, Mass.
Federal Manufacturing & Engineering Corp., 199-217 Steuben St., Brooklyn, N. Y.
Fleron & Son, Inc., M. M., 113 N. Broad St., Trenton, N. J.
Foote Pierson & Co., Inc., 75 Hudson St., Newark 4, N. J.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Gray Manufacturing Co., 16-30 Arbor St., Hartford, Conn.
Haydon Manufacturing Co., Inc., Forestville, Conn.
McElroy Manufacturing Corp., 82 Brookline Ave., Boston, Mass.
Mechanitron Corp., 711 Boylston St., Boston 16, Mass.
Reynolds Electric Co., 2650 W. Congress St., Chicago 12, Ill.
Signal Electric Mfg. Co., 1915 Broadway, Menominee, Mich.
Telegraph Apparatus Co., 325 W. Huron St., Chicago, Ill.
Telephonics Corp., 350 West 31st St., New York 1, N. Y.
Teleplex Co., 107 Hudson St., Jersey City, N. J.
Vibroplex Co., Inc., 833 Broadway, New York, N. Y.
Wallace & Tiernan Products, Inc., Belleville, N. J.
Winslow Co., 31 Fulton St., Newark 2, N. J.

Knobs

see Dials

also Pointers

Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Insulator Corp., New Freedom, Pa.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway. S., Mt. Vernon, N. Y.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland, Ohio
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
Daven Co., 191 Central Ave., Newark 4, N. J.
Davies Molding Co., Harry, 1428 N. Wells St., Chicago 10, Ill.
Diemolding Corp., Canastota, N. Y.
Eby, Inc., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Eclipse Moulded Products Co., 5151 North 32nd St., Milwaukee 9, Wisc.
Emeloid Co., 291 Laurel Ave., Arlington, N. J.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Erie Resistor Corp., 644 W. 12 St., Erie, Pa.
Garfield Mfg. Co., Garfield, N. J.
Gemloid Corp., 79-10 Albion Ave., Elmhurst, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Imperial Molded Products Corp., 2925 W. Harrison St., Chicago, Ill.
Insulation Mfg. Co., 11 New York Ave., Brooklyn, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Kurz-Kasch, Inc., 1415 S. Bway, Dayton, 1, Ohio
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Mykroy, Inc., 1917 N. Springfield Ave., Chicago 47, Ill.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
New England Radiocrafters, 1156 Commonwealth Ave., Boston 34, Mass.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Richardson Co., Melrose Park, Ill.
Rogan Brothers, 2001 S. Michigan Ave., Chicago, Ill.
Stokes Rubber Co., Jos., Taylor & Webster Sts., Trenton, N. J.
Syracuse Ornamental Co., 581 So. Clinton St., Syracuse, N. Y.
Victory Mfg. Co., 1722 W. Arcade Place, Chicago 12, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Worcester Moulded Plastics Co., 8 Grafton St., Worcester 8, Mass.

Lacquer

see Finishes

Lights

DIAL LIGHTS

Aerolux Light Corp., 653 11th Ave., New York 19, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Carlton Lamp Corp., 730 South 13th St., Newark 3, N. J.
Cinch Mfg. Corp., 2335 W. Van Buren St., Chicago, Ill.
Dial Light Co. of America, 900 Broadway, New York 3, N. Y.
Drake Mfg. Co., 1713 Hubbard St., Chicago, Ill.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
General Electric Co., Schenectady 5, N. Y.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kirkland Co., H. R., 8-10 King St., Morristown, N. J.

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Kopp Glass, Inc., 1 E. 42nd St., New York 17, N. Y.
Micarta Fabricators Inc., 5324 Ravenswood Ave., Chicago 40, Ill.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Signal Indicator Corp., 894 Broadway, New York 3, N. Y.
Tung-Sol Lamp Works, Inc., 95 Eighth Ave., Newark, N. J.
Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.

PILOT LIGHTS

Alden Products Co., 117 North Main St., Brockton 64, Mass.
Bardwell & McAllister, 7636 Santa Monica Blvd., Hollywood, Calif.
Bryant Electric Co., 1421 State St., Bridgeport, Conn.
Bud Radio, Inc., 2118 East 55 St., Cleveland 3, Ohio
Carlton Lamp Corp., 730 South 13th St., Newark 3, N. J.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Conn, Ltd., C. G., Elkhart, Ind.
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Dial Light Co. of America, Inc., 900 Broadway, New York 3, N. Y.
Drake Mfg. Co., 1713 W. Hubbard St., Chicago, Ill.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
Franklin Mfg. Corp., A. W., 175 Varick St., New York, N. Y.
General Electric Co., Schenectady 5, N. Y.
Gothard Mfg. Co., 1300 North 9th St., Springfield, Ill.
Hart Mfg. Co., 110 Bartholomew Ave., Hartford 1, Conn.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kirkland Co., H. R., 8–10 King St., Morristown, N. J.
Kopp Glass, Inc., 1 E. 42nd St., New York 17, N. Y.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Pass & Seymour, Inc., Solvay Station, Syracuse, N. Y.
Signal Indicator Corp., 894 Broadway, New York, N. Y.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wood Electric Co., Inc., C. D., 826 Broadway, New York 3, N. Y.

Lines

COAXIAL LINES

see Cable

Locknuts

see Nuts

Lockwashers

see Washers

Loudspeakers

Altec Lansing Corp., 1680 N. Vine St., Los Angeles 28, Cal.
American Communications Corp., 306 Broadway, New York, N. Y.
Atlas Sound Corp., 1443 39th St., Brooklyn, N. Y.
Austin Electronic Mfg. Co., Warren, Pa.
Bell Sound Systems, Inc., 1183 Essex Ave., Columbus, Ohio
Best Mfg. Co., 1200 Grove St., Irvington, N. J.
Boom Electric Amplifier Corp., 1227 W. Washington Blvd., Chicago, Ill.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Cinaudagraph Speakers, Inc., 3911 S. Michigan Ave., Chicago, Ill.
Consolidated Radio Products Co., 350 W. Erie St., Chicago 10, Ill.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Dilks, Inc., Norwalk, Conn.
Electronic Sound Engineering Co., 109 N. Dearborn St., Chicago 2, Ill.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Flock Process Corp., 53 W. 21st St., New York 10, N. Y. (Also 3 Quincy St., Norwalk, Conn.)
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
General Instrument Corp., 829 Newark Ave., Elizabeth F, N. J.
Guided Radio Corp., 161 Sixth Ave., New York 13, N. Y.
Hallicrafters Co., 2611 Indiana Ave., Chicago 16, Ill.
Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago, Ill.
Langevin Co., Inc., 37 W. 65th St., New York, N. Y.
Lifetime Sound Equipment Co., 1101 Adams St., Toledo, Ohio
Magnavox Co., The, 2131 Bueter Rd., Fort Wayne 4, Ind.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
National Co., Inc., 61 Sherman St., Malden. 48, Mass.
National Scientific Products Co., 5013 N. Kedzie Ave., Chicago 25, Ill.
Olesen Illuminating Co. Ltd., Otto, 1560 Vine St., Hollywood 28, Calif.
Operadio Mfg. Co., 13th & Indiana Sts., St. Charles, Ill.
Permoflux Corp., 4900 W. Grand Ave., Chicago, Ill.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Powers Electronic & Communication Co., Inc., Glen Cove, N. Y.
Quam-Nichols Co., 526 East 33rd Place, Chicago 16, Ill.
Racon Electric Co., Inc., 52 E. 19th St., New York 3, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Speakers, Inc., 221 E. Cullerton St., Chicago, Ill.
Radionic Controls, Inc., 3758 Belmont Ave., Chicago 18, Ill.
Rola Co., Inc., 2530 Superior Ave., Cleveland, Ohio
Schulmerich Electronics Co., Sellersville, Pa.
Simpson Mfg. Co., Mark, 188 West Fourth St., New York, N. Y.
Stephens Mfg. Co., 10416 National Blvd., Los Angeles 34, Calif.
Taybern Equipment Co., Inc., 120 Greenwich St., New York 6, N. Y.
Techno-Scientific Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
University Laboratories, 225 Varick St., New York, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.

Lugs & Terminals

Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
Aircraft-Marine Products, Inc., 1523 N. Fourth St., Harrisburg, Pa.
American Brass Co., Waterbury 88, Conn.
Atlas Products Corp., 30 Rockefeller Plaza, New York 20, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bead Chain Mfg. Co., 110 Mt. Grove St., Bridgeport 5, Conn.
Belden Mfg. Co., 4647 W. Van Buren St., Chicago 44, Ill.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Bud Radio, Inc., 2118 E. 55 St., Cleveland 3, Ohio
Burndy Engineering Co., 107 Bruckner Blvd., New York 54, N. Y.
Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass.
Cinch Mfg. Corp., 2335 W. Van Buren St., Chicago, Ill.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Dante Electric Mfg. Co., Bantam, Conn.
Dossert & Co., 249 Huron St., Brooklyn, N. Y.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
Franklin Mfg. Corp., A. W., 175 Varick St., New York, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Grammes & Sons, Inc., L. F., 389 Union St., Allentown 2, Pa.
Harvey Radio Laboratories, Inc., 447 Concord Ave., Cambridge, Mass.
Hatheway Mfg. Co., Bridgeport, Conn.
Heyman Mfg. Co., Kenilworth, N. J.
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.
Ilsco Copper & Tube Product Inc., Mariemont Ave., Mariemont 27, Ohio
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2460 W. George St. Chicago 18, Ill.
Kellogg Switchboard & Supply So., 6650 S. Cicero Ave., Chicago 38, Ill.
Krueger & Hudepohl, 232-8 Vine St., Cincinnati 5, Ohio
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Manufacturers Screw Products, 270 W. Hubbard St., Chicago, Ill.
Morse Co., Frank W., 301 Congress St., Boston 10, Mass.
National Fabricated Products, 2650 Belden Ave., Chicago 47, Ill.
Penn-Union Electric Corp., 315 State St. Erie, Pa.
Philmore Mfg. Co., 113 University Place New York, N. Y.
Rajah Co., Locust Ave., Bloomfield, N. J.
Schott Co. Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago 39, Ill.
Sherman Mfg. Co., H. B., Battle Creek, Mich.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South Pasadena, Calif.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Stewart Stamping Corp., 630 Central Park Ave., Yonkers 4, N. Y.
Stimpson Co., Inc., Edwin B., 74 Franklin Ave., Brooklyn 5, N. Y.
Templetone Radio Mfg. Corp., New London, Conn.
Thompson-Bremer & Co., 1640 W. Hubbard St., Chicago, Ill.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Waterbury Button Co., 335 S. Main St., Waterbury, Conn.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.
Zierick Mfg. Corp., 385 Gerard Ave., New York, N. Y.

Machinery, Printing Blue and Blue White

see Blue and Black-White Printing Machines

Machines

COIL WINDING MACHINES

Armature Coil Equipment, Inc., 2605 Vega Ave., Cleveland 3, Ohio
Automatic Manufacturing Co., 900 Passaic Ave., E. Newark, N. J.

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ELECTRONIC and ALLIED PRODUCTS

Chapman Electrical Works, P. E., 1820 Chouteau Ave., St. Louis, Mo.
Electric Service Manufacturing Co., 17th & Cambria Sts., Philadelphia 32, Pa.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Giannini & Co., Inc., G. M., 161 E. California St., Pasadena, Calif.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb.
Guthman & Co., Edwin I., 15 S. Throop St., Chicago, Ill.
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.
Kahle Engrg. Co., 1307 Seventh St., North Bergen, N. J.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.
Potter & Rayfield, Inc., Box 1042, 1570 Northside Drive, Atlanta, Ga.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Stevens Machinery Co., 1461 W. Grand Ave., Chicago 22, Ill.
Universal Winding Co., 1655 Elmwood Ave., Cranston 3, R. I.

MARKING MACHINES

see Plastics & Metal Marking

TESTING MACHINES

see Tube Mfrs'. Test Equipment

TUBE MANUFACTURING MACHINES

Ecco High Frequency Corp., 7020 Hudson Blvd., North Bergen, N. J.
Eisler Engineering Co., 740 S. 13th St., Newark 3, N. J.
Electronic Manufacturing Co., 20 Orange St., Newark 2, N. J.
Engineering Co., 27 Wright St., Newark, N. J.
International Machine Works, 2027 46th St., North Bergen, N. J.
Kahle Engineering Co., 1307 Seventh St., North Bergen, N. J.
Litton Engineering Labs., P. O. Box 749, Redwood City, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.

Magnesium

see Metals

Magnets

PERMANENT MAGNETS

Advance Transformer Co., 14 N. May St., Chicago, Ill.
Arnold Engrg. Co., 147 E. Ontario St., Chicago, Ill.
Cinaudagraph Corp., 2 Selleck St., Stamford, Conn.
Crucible Steel Co. of America, 405 Lexington Ave., New York 17, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Magnetic Corp., 2126 E. Fort St., Detroit 7, Mich.
Indiana Steel Products Co., 6 N. Michigan Ave., Chicago, Ill.
Malco Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Scherr, George D., 200 Lafayette St., New York, N. Y.
Simonds Saw & Steel Co., Lockport, N. Y.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South Pasadena, Calif.
Taylor-Wharton Iron & Steel Co., Highbridge, N. J.
Thomas & Skinner Steel Products Co., 1120 E. 23d St., Indianapolis, Ind.
Tri-United Plastics Corp., 390 Nye Ave., Irvington, N. J.

Metal Marking Machines —

see Plastics & Metal Marking

Metal Plating on Plastics—

see Plating-Metal

Metals

ALUMINUM

Aluminum Co. of America, Gulf Bldg., Pittsburgh, Pa.
Aluminum Finishing Corp., 1119 E. 22nd St., Indianapolis, Ind.
Belmont Smelting & Refining Works, Inc., 330 Belmont Ave., Brooklyn 7, N. Y.
Fairmont Aluminum Co., Fairmont, West Va.
Reynolds Metal Co., Federal Reserve Bldg., Richmond, Va.
Uniform Tubes, Shurs Lane & Lauriston St., Roxborough, Philadelphia, Pa.

MAGNESIUM

American Magnesium Corp., 2210 Harvard Ave., Cleveland, Ohio
Belmont Smelting & Refining Works, Inc., 330 Belmont Ave., Brooklyn 7, N. Y.
Bohn Aluminum & Brass Corp., Lafayette Bldg., Detroit, Mich.
Dow Chemical Co., Midland, Mich.

NICKEL

Ingersoll Steel & Disc Co., New Castle, Ind.
International Nickel Co., 67 Wall St., New York 5, N. Y.
Lukens Steel Co., Coatesville, Pa.
Superior Metal Corp., Clearing, Ill.

POWDERED METAL PRODUCTS

American Electro Metal Corp., 320 Yonkers Ave., Yonkers, N. Y.
Belmont Smelting & Refining Works, Inc., 330 Belmont Ave., Brooklyn 7, N. Y.
Chrysler Corp., Amplex Div., Detroit, Mich.
Cleveland Tungsten, Inc., 10200 Meech Ave., Cleveland, Ohio
Crowley & Co., Inc., Henry L., 1 Central Ave., West Orange, N. J.
Division Lead Co., 836 W. Kinzie St., Chicago 22, Ill.
Foote Mineral Co., 1609 Summer St., Philadelphia, Pa.
General Aniline & Film Corp., Special Products Sales Dept., 270 Park Ave., New York 17, N. Y.
Goldsmith Bros. Smelting & Refining Co., 58 East Washington St., Chicago, Ill.
Handy & Harman, 82 Fulton St., New York 7, N. Y.
Johnson Bronze Co., New Castle, Pa.
Keystone Carbon Co., Inc., 1935 State St., St. Marys, Pa.
Magna Mfg. Co., 444 Madison Ave., New York, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Mepham Corp., G. S., 2001 Lynch Ave., East St. Louis, Ill.
Micro-Ferrocart Products Div., Maguire Industries, Inc., Greenwich, Conn.
Moraine Products Div., General Motors Corp., Dayton, Ohio
National Lead Co., 111 Broadway, New York 6, N. Y.
Powder Metallurgy Corp., 30-48 Greenpoint Ave., Long Island City, N. Y.
Wickwire Spencer Metallurgical Corp., 260 Sherman St., Newark, N. J.

SPECIAL METALS

Allegheny Ludlum Steel Corp., Brackenridge, Pa.
Alloy Metal Wire Co., Prospect Park, Pa.
American Platinum Works, New Jersey R. R. Ave., at Oliver St., Newark, 5, N. J.
Baker & Co., 113 Astor St., Newark 5, N. J.
Belmont Smelting & Refining Works, Inc., 330 Belmont Ave., Brooklyn 7, N. Y.
Bishop & Co., Platinum Works, J., 12 Channing Ave., Malvern, Pa.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Callite Tungsten Corp., 544 39th St., Union City, N. J.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Chace Co., W. M., 1600 Beard Ave., Detroit, Mich.
Cohn & Co., Sigmund, 44 Gold St., New York, N. Y.
Cross, H., 15 Beekman St., New York, N. Y.
Division Lead Co., 836 W. Kinzie St., Chicago 22, Ill.
Driver Co., William B., 150 Riverside Ave., Newark, N. J.
Driver Harris Co., Harrison, N. J.
Fansteel Metallurgical Corp., 2200 Sheridan Rd., North Chicago, Ill.
Foote Mineral Co., 1609 Summer Street, Philadelphia, Pa.
General Plate Div. Metals & Controls Corp., 34 Forest St., Attleboro, Mass.
Goldsmith Bros. Smelting & Refining Co., 58 E. Washington St., Chicago, Ill.
Handy & Harman, 82 Fulton St., New York 7, N. Y.
Haydu Bros., Mt. Bethel Rd., Plainfield, N. J.
International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.
Kemet Laboratories Co., Inc., West 117th St. & Madison Ave., Cleveland 1, Ohio
King Laboratories, Inc., 205 Oneida St., Syracuse 4, N. Y.
Makepeace Co., D. E., Attleboro, Mass.
Ney Co., J. M., Hartford, Conn.
North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y.
Olin Industries, East Alton, Ill.
Peerless Roll Leaf Co., Inc., 4517 New York Ave., Union City, N. J.
Rapid Electroplating Process, Inc., 1414 S. Wabash Ave., Chicago 5, Ill. (electroplating & treating)
Revere Copper & Brass Inc., 230 Park Ave., New York 17, N. Y.
Riverside Metal Co., Riverside, N. J.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Simonds Saw & Steel Co., Lockport, N. Y.
Swedish Iron & Steel Corp., 17 Battery Place, New York, N. Y.
Western Brass Mills, Div. of Olin Industries, Inc., East Alton, Ill.
Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.
Wickwire Spencer Metallurgical Corp., 260 Sherman St., Newark, N. J.
Wilson Co., H. A., 105 Chestnut St., Newark 5, N. J.

STEEL ELECTRICAL

Allegheny Ludlum Steel Corp., Brackenridge, Pa.
American Rolling Mill Co., Curtis St., Middletown, Ohio
American Steel & Wire Co., Rockefeller Building, Cleveland 13, Ohio
Carnegie-Illinois Steel Corp., Carnegie Bldg., Pittsburgh, Pa.
Crucible Steel Co., of America, 405 Lexington Ave., New York, N. Y.
Empire Steel Corporation, N. Bowman St., Mansfield, Ohio
Follansbee Steel Corp., Third & Liberty Sts., Pittsburgh, Pa.
Granite City Steel Co., Granite City, Ill.
Newport Rolling Mill Co., Ninth & Lowell Sts., Newport, Ky.
Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio
Thomas Steel Co., Delaware Ave., Warren Ohio
Union Drawn Steel Div., Republic Steel Corp., Harsh Ave., S. E. Massillon, Ohio
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wheeling Steel Corp., Wheeling Steel Corp., Bldg., Wheeling, W. Va.
Youngstown Sheet & Tube Co., Stambaugh Bldg., Youngstown, Ohio

THERMOSTATIC METALS

Baker & Co., 113 Astor St., Newark 5, N. J.
Brainin Co., C. S., 233 Spring St., New York 13, N. Y.
Callite Tungsten Corp., 544 39th St., Union City, N. J.
Chace Co., W. M., 1600 Beard Ave., Detroit, Mich.
General Plate Div., Metals & Controls Corp., 34 Forest St., Attleboro, Mass.
Wilson Co., H. A., 105 Chestnut St., Newark 5, N. J.

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Meters

AMMETERS

Associated Research Inc., 231 S. Green St., Chicago 7, Ill.
Boes Co., W. W., 3001 Salem Ave., Dayton, 3, Ohio
Bristol Co., Waterbury 91, Conn.
Burlington Instrument Co., 214 North 4th St., Burlington, Iowa
Burton-Rogers Co., 857 Boylston Street, Boston 16, Mass.
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
De Jur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Electric Auto-Lite Corp., Toledo 1, Ohio
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electro-Mechanical Instrument Co., 812 Chestnut St., Perkasie, Pa.
Electronic Development Co., 1336 North Saddle Creek Road, Omaha 3, Nebr.
Esterline-Angus Co., Inc., P. O. Box 597, Indianapolis, Ind.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Electronic Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
MB Manufacturing Co., New Haven, Conn.
Marion Electrical Instrument Co., Manchester, N. H.
Meters, Inc., 915 Riveria Drive, Indianapolis 5, Ind.
Norton Electrical Instrument Co., 79 Hilliard St., Manchester, Conn.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Readrite Meter Works, College Ave., Bluffton, Ohio
Reliance Instrument Co., 715 N. Kedzie Ave., Chicago, Ill.
Rhamstine, J. Thos., 301 Beaubien St., Detroit 26, Mich.
Roller-Smith, Bethlehem, Pa.
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Sensitive Research Instrument Co., 9 Elm Ave., Mt. Vernon, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sun Mfg. Co., 6323 Avondale Ave., Chicago, Ill.
Superior Instruments Co., 227 Fulton St., New York 7, N. Y.
Supreme Instruments Corp., Greenwood, Miss.
Technical Products Co., 158 Madison Ave., at Third St., Memphis, Tenn.
Thwing-Albert Instrument Co., Penn St., & Pulaski Ave., Philadelphia 44, Pa.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Western Electro-Mechanical Co., Inc., 300 Broadway, Oakland, Calif.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Freylinghuysen Ave., Newark 5, N. Y.

FIELD INTENSITY METERS

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Fada Radio & Electric Co., Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Freed Radio Corp., 200 Hudson St., New York, N. Y.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Marion Electrical Instrument Co., Manchester, N. H.
Measurements Corp., Boonton, N. J.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Radio Corp. of America, RCA Victor Div., Camden, New Jersey
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.

FREQUENCY METERS

Aero Communications, Inc., 231 Main St., Hempstead, L. I., N. Y.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bendix Radio Div. of Bendix Aviation Corp., Baltimore 4, Md.
Biddle Co., James G., 1213 Arch St., Philadelphia, Pa.
Browning Laboratories, Inc., 750 Main St., Winchester, Mass.
Burlington Instrument Corp., 214 North 4th St., Burlington, Iowa
Burnett Radio Lab., Wm. W. L., 4814 Idaho St., San Diego, Calif.
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Collins Radio Co., 855-35th St., N. E. Cedar Rapids, Iowa
Cardwell Mfg. Corp., Allen D., 81 Prospect St., Brooklyn, N. Y.
Conn Ltd., C. G., Elkhart, Ind.
Daven Co., 191 Central Ave., Newark 4, N. J.
Doolittle Radio, Inc., 7421 South Loomis Blvd., Chicago, Ill.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Erco Radio Laboratories, Inc., Fenimore Ave., Hempstead, N. Y.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Fada Radio & Electric Co., Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Ferris Instrument Co., 110-112 Cornelia St., Boonton, N. J.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Gurley, W. & L. E., 514 Fulton St., Troy, N. Y.
Harvey Radio Laboratories, Inc., 447 Concord Ave., Cambridge, Mass.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia, Pa.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles 7, Calif.
J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, Long Island, N. Y.
Lampkin Laboratories, Bradenton, Fla.
Lavoie Laboratories, Mattawan-Freehold Rd., Morganville, N. J.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Link, Fred M., 125 West 17 St., New York, N. Y.
Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., 61 Sherman St., Malden 48, Mass.
North American Philips Co., Inc., 100 East 42nd St., New York, N. Y.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Roller-Smith, Bethlehem, Pa.
Schuttig & Co., 9th & Kearney St., N.E., Washington 17, D. C.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, New York
Telicon Corp., 305 East 63rd St., New York, N. Y.
Transmitter Equipment Mfg. Co. Inc., 345 Hudson St., New York 14, N. Y.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

GALVANOMETERS

Boes Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Central Scientific Co., 1700 Irving Park Blvd., Chicago 13, Ill.
Communication Measurements Laboratory, 120 Greenwich St., New York, N. Y.
Consolidated Engineering Corp., 596 E. Colorado St., Pasadena 1, Calif.
De Jur Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Engelhard, Inc., Charles, 233 New Jersey R. R. Ave., Newark 5, N. J.
Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.
G-M Laboratories, Inc., 4313 N. Knox Ave., Chicago, Ill.
General Electric Co., Schenectady 5, N. Y.
Geophysical Instrument Co., Key Blvd. & Nash St., Arlington, Va.
Giannini & Co., Inc., G. M., 161 E. California St., Pasadena, Calif.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Helland Research Corp., 130 East Fifth St., Denver 9, Colo.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
MB Manufacturing Co., 1060 State St., New Haven, Conn.
Marion Electrical Instrument Co., Manchester, N. H.
Meters, Inc., 915 Riveria Drive, Indianapolis 5, Ind.
Miller Corp., Wm., 362 W. Colorado St., Pasadena, Calif.
Pfaltz & Bauer, Inc., 350 Fifth Ave., New York, N. Y.
Portable Products Corp., C. J. Tagliabue Div., 550 Park Ave., Brooklyn 5, N. Y.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Roller-Smith, Bethlehem, Pa.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Sanborn Co., 39 Osborne St., Cambridge 39, Mass.
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Sensitive Research Instrument Co., 9 Elm Ave., Mt. Vernon, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Technical Products Co., 158 Madison Ave., at Third St., Memphis, Tenn.
Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Pa.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Winslow Co., 31 Fulton St., Newark 2, N. J.

LIGHT METERS

De Jur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
General Electric Co., Schenectady 5, N. Y.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
MB Manufacturing Co., 1060 State St., New Haven, Conn.
Marion Electrical Instrument Co., Manchester, N. H.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Pfaltz & Bauer, Inc., 350 Fifth Ave., New York, N. Y
Photovolt Corp. 95 Madison Ave., New York 16, N. Y.
Pho-Tron Instrument Co., 5713 Euclid Ave., Cleveland, Ohio

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amstine, J. Thos., 301 Beaubien St., Detroit 26, Mich.
entific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
chnical Products Co., 158 Madison Ave. at 3rd St., Memphis, Tenn.
lch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
stinghouse Electric Corp., East Pittsburgh, Pa.
ston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

MODULATION METERS

rker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
es Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
ites Radio Co., 220 Hampshire St., Quincy, Ill.
neral Electric Co., Schenectady 5, N. Y.
neral Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
wis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
B Mfg. Co., 1060 State St., New Haven, Conn.
egard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
adio Corp. of America, RCA Victor Div., Camden, N. J.
ndt Engineering Co., 4757 Ravenswood Ave., Chicago, Ill.
estinghouse Electric Corp., East Pittsburgh, Pa.
eston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

OHMMETERS

ssociated Research, Inc., 231 South Green St., Chicago 7, Ill.
iddle Co., James G., 1213 Arch St., Philadelphia, Pa.
oes Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
urlington Instrument Corp., 214 North 4th St., Burlington, Iowa
e Jur Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
astern Electronics Corp., 41 Chestnut St., New Haven, Conn.
lectric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
lectronic Development Co., 1336 North Saddle Creek Road, Omaha 3, Nebr.
spey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
eneral Electric Co., Schenectady 5, N. Y.
eneral Electronics Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
eneral Radio Co., 275 Massachusetts Aye., Cambridge 39, Mass.
ray Instrument Co., 64½ W. Johnson St., Germantown, Philadelphia, Pa.
renby Mfg. Co., Plainville, Conn.
Hatry & Young, 203 Ann St., Hartford, Conn.
Hearing Aid Labs, 1404 Franklin St., Michigan City, Ind.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Holtzer-Cabot Signal Division, 400 Stuart St., Boston 17, Mass.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Marion Electrical Instrument Co., Manchester, N. H.
MB Mfg. Co., 1060 State St., New Haven, Conn.
Norton Electrical Instrument Co., 79 Hilliard St., Manchester, Conn.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Radio City Products Co., 127 W. 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, New Jersey
Radio Design Co., 1353 Sterling Place, Brooklyn, N. Y.
Reiner Electronics Co., 152 W. 25th St., New York, N. Y.
Roller-Smith, Bethlehem, Pa.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
Sticht Co., Inc., Herman H., 27 Park Place, New York 7, N. Y.
Superior Instruments Co., 227 Fulton St., New York 7, N. Y.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Techno Scientific Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Pa.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Triumph Mfg. Co., 913 W. Van Buren St., Chicago 7, Ill.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Winslow Co., 31 Fulton St., Newark 2, N. J.

pH METERS, RECORDERS & COMPARATORS

Bristol Company, Waterbury 91, Conn.
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Central Scientific Co., 1700 Irving Park Blvd., Chicago 13, Ill.
Coleman Electric Co., 318 Madison St., Maywood, Ill.
Colloid Equipment Co., Inc., 50 Church St., New York, N. Y.
Commercial Research Labs., Inc., 20 Bartlett Ave., Detroit 3, Mich.
Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.
Foxboro Co., Foxboro, Mass.
Gamma Instrument Co., Inc., 95 Madison Ave., New York 16, N. Y.
General Electric Co., 1 River Rd., Schenectady 5, N. Y.
Hellige, Inc., 3718 Northern Blvd., Long Island City 1, N. Y.
LaMotte Chemical Products Co., Towson 4, Baltimore, Md.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
MB Mfg. Co., 1060 State St., New Haven, Conn.
Machlett & Son, E., 220 East 23rd St., New York 10, N. Y.
National Technical Labs., 820 Mission St., South Pasadena, Calif.
Pfaltz & Bauer, Inc., 350 Fifth Ave., New York, N. Y.
Portable Products Corp., C. J. Tagliabue Div., 550 Park Ave., Brooklyn 5, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y.
Rascher & Betzold, 829-835 Orleans St., Chicago, Ill.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Taylor & Co., W. A., 7300 York Road, Baltimore 4, Md.
Technical Products Co., P. O. Box 93, 158 Madison Ave. at 3rd St., Memphis, Tenn.
Thwing-Albert Instrument Co., Penn St. at Pulaski Ave., Philadelphia 44, Pa.
Wallace & Tiernan Products Inc., Belleville, N. J.
Welch Manufacturing Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Wilkens-Anderson Co., 111 N. Canal St., Chicago 6, Ill.

PHASE ANGLE METERS

Amplifier Co. of America, 396 Broadway, New York, N. Y.
Andrew Co., 363 East 75th St., Chicago 19, Ill.
Edison, Inc., Thomas A., Instrument Div., 51 Lakeside Ave., West Orange, N. J.
General Electric Co., Schenectady 5, N. Y.
Hickok Electrical Instrument Co., 10514 Du Pont Ave., Cleveland, Ohio
Johnson Co., E. F. Waseca, Minn.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Sorenson & Co., 375 Fairfield Ave., Stamford, Conn.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

POWER LEVEL METERS

see Indicators

"Q" METERS

Boonton Radio Corp., Boonton, N. J.
Communication Parts, 1101 N. Paulina St., Chicago 22, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electronic Measurements Co., Red Bank, N. J.
MB Mfg. Co., 1060 State St., New Haven, Conn.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.

THERMOCOUPLE METERS

Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio
Boes Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
Brown Instrument Co., 4428 Wayne Ave., Philadelphia 44, Pa.
Burlington Instrument Corp., 214 North Fourth St., Burlington, Iowa
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Electronic Development Co., 1336 North Saddle Creek Road, Omaha 3, Nebr.
Foxboro Co., Foxboro, Mass.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Illinois Testing Labs., Inc., 420 N. LaSalle St., Chicago, Ill.
J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
MB Mfg. Co., 1060 State St., New Haven, Conn.
Meters, Inc., 915 Riveria Drive, Indianapolis 5, Ind.
Portable Products Corp., C. J. Tagliabue Div., 550 Park Ave., Brooklyn 5, N. Y.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Roller-Smith, Bethlehem, Pa.
Sensitive Research Instrument Co., 9 Elm Ave., Mt. Vernon, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Thwing Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Pa.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Illinois
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

TIME METERS

Amercian Time Products, Inc., 580 Fifth Ave., New York 19, N. Y.
Cramer Co., R. W., Centerbrook, Conn.
Electric Tachometer Corp., Broad & Spring Garden Sts., Philadelphia, Pa.
Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis, Ind.
General Electric Co., Schenectady 5, N. Y.
Haydon Manufacturing Co. Inc., Forestville, Conn.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Industrial Timer Corp., 117 Edison Place, Newark 5, N. J.
J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
National Instrument Co., 246 Walnut St., Newtonville 60, Mass.
Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, Long Island, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rowe Radio Research Laboratory Co., 2422 N. Pulaski Rd., Chicago 39, Ill.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Warren Telechron Co., Homer Ave., Ashland, Mass.
Westinghouse Electric Corp., East Pittsburgh, Pa.

VACUUM TUBE VOLTMETERS

American Radio Co., 611 E. Garfield Ave., Glendale, Calif.
Ballantine Laboratories, Inc., Boonton, N. J.
Barber Labs, Alfred W., 34-04 Francis Lewis Blvd., Flushing, New York.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electronic Development Co., 1336 North Saddle Creek Road, Omaha 3, Nebr.

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Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Ferris Instrument Co., 110-112 Cornelia St. Boonton, N. J.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Grenby Mfg. Co., Plainville, Conn.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 1, Ohio
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lawton Products Co., Inc., 624 Madison Ave., New York 22, N. Y.
MB Manufacturing Co., 1060 State St., New Haven, Conn.
Measurements Corp., Boonton, N. J.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
National Technical Laboratories, 820 Mission St., South Pasadena, Calif.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Design Co., 1353 Sterling Place, Brooklyn, N. Y.
Reiner Electronics Co., 152 W. 25th St., New York, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sound Apparatus Co., 233 Broadway, New York 7, N. Y.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
Standard Instruments Corp., 568 Prospect Ave., New York 55, N. Y.
Superior Instruments Co., 227 Fulton St., New York 7, N. Y.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Technical Devices Corp., Beaufort & Eagle Rock Ave., Roseland, N. J.
Televiso Products, Inc., 6533 N. Olmstead Ave., Chicago, Ill.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
White Research, 899 Boylston St., Boston, Mass.

VOLTMETERS

Aerolux Light Corp., 653 Eleventh Ave., New York 19, N. Y.
Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Ballantine Laboratories, Inc., Boonton, N. J.
Boes Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
Bristol Co., Waterbury 91, Conn.
Burlington Instrument Co., 214 North 4th St., Burlington, Iowa
Burton-Rogers Co., 857 Boylston St., Boston 16, Mass.
De Jur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electro-Mechanical Instrument Co., 812 Chestnut St., Perkasie, Pa.
Electronic Development Co., 1336 North Saddle Creek Road, Omaha 3, Nebr.
Engelhard, Inc., Charles, 233 N. J. R. R. Ave., Newark, N. J.
Espey Mfg. Co., Inc., 33 West 46th St., New York, N. Y.
Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis, Ind.
Ferranti Electric, Inc., 30 Rockfeller Plaza, New York 20, N. Y.
Ferris Instrument Co., 110-112 Cornelia St., Boonton, N. J.
G-M Laboratories, Inc., 4313 N. Knox Ave., Chicago, Ill.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hatry & Young, 203 Ann St., Hartford, Conn.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 1, Ohio
J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Marion Electrical Instrument Co., Manchester, N. H.
MB Manufacturing Co., 1060 State St., New Haven, Conn.
Meck Industries, John, Plymouth, Ind.
Meters, Inc., 915 Riveria Drive, Indianapolis 5, Ind.
Norton Electrical Instrument Co., 79 Hilliard St., Manchester, Conn.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Radio City Products Co., 127 W. 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Readrite Meter Works, College Ave., Bluffton, Ohio
Reliance Instrument Co., 715 N. Kedzie Ave., Chicago, Ill.
Rhamstine, J. Thos., 301 Beaubien St., Detroit, Mich.
Roller-Smith, Bethlehem, Pa.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Sensitive Research Instrument Co., 9 Elm St., Mt. Vernon, N. Y.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sun Mfg. Co., 6323 Avondale Ave., Chicago, Ill.
Superior Instruments Co., 227 Fulton St., New York 7, N. Y.
Supreme Instruments Corp., Greenwood, Miss.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Televiso Products, Inc., 6533 N. Olmstead Ave., Chicago, Ill.
Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Pa.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Freylinghuysen Ave., Newark 5, N. J.

VOLUME INDICATOR METERS

Amplifier Co. of America, 396 Broadway, New York, N. Y.
Boes Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
Daven Co., 191 Central Ave., Newark 4, N. J.
De Jur Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Eastern Electronics Corp., 41 Chester St., New Haven, Conn.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
MB Mfg. Co., New Haven, Conn.
Marion Electrical Instrument Co., Manchester, N. H.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meters, Inc., 915 Riveria Drive, Indianapolis 5, Ind.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rek-O-Kut Co., 173 Lafayette St., New York 13, N. Y.
Scientific Service Laboratories, 2225 So. State St., Los Angeles 7, Calif.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Worcester Moulded Plastics Co., 8 Grafton St., Worcester 8, Mass.

WATTMETERS

Bristol Co., Waterbury 91, Conn.
Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis, Ind.
General Electric Co., Schenectady 5, N. Y.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Roller-Smith, Bethlehem, Pa.
Sensitive Research Instrument Co., 9 Elm Ave., Mt. Vernon, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

Mica

Asheville Mica Co., 5 River Rd., Biltmore, N. C.
Brand & Co., William, 276 Fourth Ave., New York 10, N. Y.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Cornell-Dubilier Electric Corp., 1000 Hamilton Blvd., South Plainfield, N. J.
English Mica Co., 220 E. 42d St., New York, N. Y.
Ford Radio & Mica Corp., 538 63rd St., Brooklyn, N. Y.
General Electric Co., Schenectady 5, N. Y.
Huse Liberty Mica Co., 171 Camden St., Boston, Mass.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
International Products Corp., Baltimore 18, Md.
Macallen Co., 16 Macallen St., Boston, Mass.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
Munsell & Co., Eugene, 200 Varick St., New York, N. Y.
New England Mica Co., Waltham, Mass.
New Hampshire Mica & Mining Co., Washington St., Keene, N. H.
Philadelphia Mica Corp., 3515 N. 10th St., Philadelphia 40, Pa.
Schoonmaker Insulation Co., Inc., A. O., 635 Greenwich St., New York 14, N. Y.
Southern Mica Co., Johnson City, Tenn.
Spruce Pine Mica Co., Spruce Pine, N. C.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Tar Heel Mica Co., Plumtree, N. C.
U. S. Mica Mfg. Co., 1521 Circle Ave., Forest Park, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Microammeters

see Ammeters

Microfaradmeters

see Bridges

Micrometers

ELECTRONIC MICROMETERS

Carson Micrometer Corp., Box 57, Little Falls, N. J.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Televiso Products, Inc., 6533 N. Olmsted Ave., Chicago, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.

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ELECTRONIC and ALLIED PRODUCTS

Microphones

American Microphone Co., 1915 S. Western Ave., Los Angeles, Calif.
Amperite Co., 561 Broadway, New York, N. Y.
Astatic Corp., Conneaut, Ohio
Aurex Corp., 1117 N. Franklin St., Chicago, Ill.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Aviometer Corp., 370 West 35th St., New York 1, N. Y.
Ballantine Laboratories, Inc., Boonton, N. J.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
California Telephone & Elec. Co., 6075 W. Pico Blvd., Los Angeles 35, Calif.
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Eby, Inc., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Electro Voice Corp., 1239 South Bend Ave., South Bend, Ind.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
Globe Phone Mfg. Corp., 2 Linden St., Reading, Mass.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Lektra Labs, Inc., 30 East Tenth St., New York, N. Y.
Lifetime Sound Equipment Co., 1101 Adams St., Toledo, Ohio
Magnavox Co., 2131 Bueter Rd., Fort Wayne 4, Ind.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Massa Laboratories, Inc., 3868 Carnegie Ave., Cleveland, Ohio (Laboratory Standards)
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Minerva Corp. of America, 238 William St., New York 7, N. Y.
Permoflux Corp., 4900 W. Grand Ave., Chicago, Ill.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Quam-Nichols Co., 526 East 33rd Place, Chicago 16, Ill.
Racon Electric Co., 52 East 19th St., New York 3, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.
Remler Co. Ltd., 2101 Bryant St., San Francisco 10, Calif.
Shure Brothers, 225 W. Huron St., Chicago, Ill.
Telephonics Corporation, 350 West 31st St., New York, N. Y.
Tibbetts Laboratories, Camden, Maine
Turner Co., 909 17th St., Cedar Rapids, Iowa
Universal Microphone Co., 424 Warren Lane, Inglewood, Calif.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.

Microphone Stands

see Stands, Microphone

Microscopes

ELECTRON MICROSCOPES

Farrand Optical Co., Inc., Bronx Blvd. at 238th St., New York 66, N. Y.
General Electric Co., Schenectady 5, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.

Milliammeters

see Ammeters

Mirrors

American Lens Co., Inc., 45 Lispenard St., New York 13, N. Y.
Austin Co., O., 42 Greene St., New York, N. Y.
Bache & Co., Semon, 636 Greenwich St., New York 14, N. Y.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N. Y.
Farrand Optical Co., Bronx Blvd., & East 238th St., New York 6, N. Y.
Glendale Optical Co., 250 Pennsylvania Ave., Brooklyn, N. Y.
Laboratory Specialties, 144 South Wabash St., Wabash, Ind.
Maberg Optical, Inc., 235 East 45th St., New York 17, N. Y.
Mogey & Sons, Inc., Wm., 76 Interhaven Ave., Plainfield, N. J.
Pancro Mirrors, Inc., 2958 Los Feliz Blvd., Los Angeles, Calif.
Practo Photo Access. Corp., 383 Pearl St., Brooklyn, N. Y.
Spencer Lens Co., Buffalo 11, N. Y.
Zenith Optical Laboratory, 123 West 64th St., New York 23, N. Y.

Moisture Proofing Equipment

General Electric Co., Schenectady 5, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Production Engineering Corp., 666 Van Houten Ave., Clifton, N. J.

Monitors, Broadcast

Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Doolittle Radio, Inc., 7421 S. Loomis Blvd., Chicago, Ill.
DuMont Laboratories, Inc., Allen B., 2 Main Ave., Passaic, N. J.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Hart & Co., Inc., Frederick, Recordgraph Div., 350 Madison Ave., New York 17, N. Y.
Howard Radio Co., 1735 Belmont Ave., Chicago 13, Ill.
Link, Fred M., 125 West 17th St., New York, N. Y.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Engineering Laboratories, Inc., 35-54 36th St., Long Island City, N. Y.
Transmitter Equipment Mfg. Co. Inc., 345 Hudson St., New York 14, N. Y.

Motor Controls

see Controls, Motor

Motor-Generators

see Generators

Motors

FRACTIONAL HORSEPOWER and MINIATURE

Air Associates, Inc., Teterboro, N. J.
Air-Way Electric Appliance Corp., 2101 Auburn Ave., Toledo, Ohio
Alliance Mfg. Co., Lake Park Blvd., Alliance, Ohio
Anco Products Company, Paterson, N. J.
Arma Corp., 254 36th St., Brooklyn, N. Y.
Baldor Electric Co., 4353 Duncan Ave., St. Louis, Mo.
Barber-Colman Co., River & Loomis Sts., Rockford, Ill.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, North Hollywood, Calif.
Bodine Electric Co., 2262 W. Ohio St., Chicago, Ill.
Bogue Electric Company, Paterson, N. J.
Brown-Brockmeyer Co., 1000 S. Smithville Rd., Dayton 1, Ohio
Burke Electric Co., 12th & Cranberry Sts., Erie, Pa.
Carter Motor Co., 1606 Milwaukee Ave., Chicago 47, Ill.
Century Electric Co., 1806 Pine St., St. Louis 3, Mo.
Clements Mfg. Co., 6650 S. Narragansett Ave., Chicago, Ill.
Controls Corp., 98 Union St., Worcester 8, Mass.
Delco Products Div., General Motors Corp., 329 E. First St., Dayton, Ohio
Delco Appliance Division, General Motors Corp., 391 Lyell Ave., Rochester, N. Y.
Diehl Mfg. Co., Finderne Plant, Somerville, N. J.
Dumore Co., 14th & Racine Sts., Racine, Wis.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Elcor, Inc., 1501 W. Congress St., Chicago 7, Ill.
Electric Auto-Lite Co., Toledo 1, Ohio
Electric Indicator Co., 21 Parker Ave., Stamford, Conn.
Electric Motor Corp., Racine, Wis.
Electric Specialty Co., 211 South St., Stamford, Conn.
Electrical Engrg. & Mfg. Corp., 4606 W. Jefferson Blvd., Los Angeles 16, Calif.
Electrolux Corporation, Old Greenwich, Conn.
Emerson Electric Mfg. Co., 1824 Washington Ave., St. Louis 3, Mo.
Fairchild Camera & Instrument Corp., 475 Tenth Ave., New York 18, N. Y.
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
Franklin Transformer Mfg. Co., 65 22nd Ave., N. E., Minneapolis 13, Minn.
General Electric Co., Schenectady 5, N. Y.
General Industries Co., Taylor & Olive Sts., Elyria, Ohio
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wisc.
Gorrell & Gorrell, 40 Littlefield Rd., Newton Center, Mass.
Hamilton Beach Company, Racine, Wisc.
Hansen Mfg. Co., Inc., Princeton, Ind.
Heinze Electric Co., Lowell, Mass.
Holtzer-Cabot, Signal Div., 400 Stuart St., Boston 17, Mass.
Howell Electric Motors Company, Howell, Mich.
Janette Mfg. Co., 556 W. Monroe St., Chicago 40, Ill.
Kingston-Conley Electric Co., 68 Brook Ave., North Plainfield, N. J.
Kollsman Instrument Div. of Square D Company, 80-08 45th Ave., Elmhurst, N. Y.
Lamb Electric Co., Kent, Ohio
Lear, Incorporated, Piqua, Ohio
Leece-Neville Company, 5363 Hamilton Ave. N. E., Cleveland 14, Ohio
Leland Electric Co., 1501 Webster St., Dayton, Ohio
Marathon Electric Mfg. Corp., Randolph & Cherry Sts., Wausau, Wisc.
Master Electric Co., 126 Davis Ave., Dayton, Ohio
Merkle-Korff Gear Co., 213 N. Morgan St., Chicago 7, Ill.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
Ohio Electric Mfg. Co., 5908 Maurice Ave., Cleveland 4, Ohio
Oster Mfg. Co. of Illinois, John, Genoa, Ill.
Otis Elevator Company, Yonkers, N. Y.
Packard Electric Div. of General Motors Corp., Warren, Ohio
Peerless Electric Co., 740 W. Market St., Warren, Ohio
Pioneer Gen-E-Motor Corp., 5841 W. Dickens Ave., Chicago 39, Ill.
Radex Corp. of America, 53 West Jackson Blvd., Chicago 4, Ill.
Redmond Co. Inc., Monroe St., Owosso, Mich.
Reynolds Electric Co., 2650 W. Congress St., Chicago 12, Ill.
Robbins & Myers, 1345 Lagonda Ave., Springfield, Ohio
Russell Electric Co., 364 W. Huron St., Chicago 10, Ill.
Signal Electric Mfg. Co., 1915 Broadway, Menominee, Mich.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Smith Mfg. Co., F. A., P. O. Box 509, Rochester 2, N. Y.

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Speedway Mfg. Co., 1834 S. 52nd Avenue, Cicero 50, Ill.
Star Electric Motor Co., 200 Bloomfield Ave., Bloomfield, N. J.
Sunlight Electrical Div., General Motors Corp., 523 Dana Ave., Warren, Ohio
Thermador Elec. Mfg. Co., 5119 S. Riverside Drive, Los Angeles 22, Calif.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Victor Electric Products, Inc., 2950 Robertson Ave., Cincinnati 9, Ohio
Wagner Electric Corp., 6400 Plymouth Ave., St. Louis, Mo.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago 47, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wincharger Corp., 7th & Division, Sioux City, Iowa

PHONOGRAPH

Alliance Mfg. Co., Lake Park Blvd., Alliance, Ohio
Autocrat Radio Co., 3855 N. Hamilton Ave., Chicago, Ill.
Garrard Sales Corp., 401 Broadway, New York 13, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Industries Co., Taylor & Olive Sts., Elyria, Ohio
Pacific Sound Equipment Co., 1534 Cahuenga Blvd., Hollywood, Calif.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, New Jersey
Robbins & Myers, 1345 Lagonda Ave., Springfield, Ohio
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Thermador Elec. Mfg. Co., 5119 S. Riverside Drive, Los Angeles 22, Calif.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago 47, Ill.

TIMING

Alliance Mfg. Co., Lake Park Blvd., Alliance, Ohio
Barber-Colman Co., Rockford, Ill.
Bodine Electric Co., 2262 W. Ohio St., Chicago, Ill.
Delco Appliance Division, General Motors Corp., Rochester, N. Y.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
General Electric Co., Schenectady 5, N. Y.
Gilbert Clock Co., Wm. L., Winsted, Conn.
Hansen Mfg. Co., Princeton, Ind.
Haydon Manufacturing Co., Inc., Forestville, Conn.
Holtzer-Cabot Signal Division, 400 Stuart St., Boston 17, Mass.
Ingraham Clock Co., Bristol, Conn.
Leich Electric Co., 565 W. Washington Blvd., Chicago 6, Ill.
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Lux Clock Manufacturing Co., 95 Johnson St., Waterbury, Conn.
Merkle-Korff Gear Co., 213 N. Morgan St., Chicago 7, Ill.
Ohio Electric Mfg. Co., 5908 Maurice Ave., Cleveland 4, Ohio
Quality Electric Co., Ltd., 1235 E. Olympic Blvd., Los Angeles 21, Calif.
Reynolds Electric Co., 2650 W. Congress St., Chicago 12, Ill.
Russell Electric Co., 364 W. Huron St., Chicago 10, Ill.
Speedway Mfg. Co., 1834 S. 52nd Ave. Cicero 50, Ill.
Square D Co., 6060 Rivard St., Detroit 11, Mich.
Synchronous Products, Inc., 4513 Brooklyn Ave., Cleveland 9, Ohio
Thompson Clock Co., H. C., Bristol, Conn.
Times Telephoto Equipment, Inc., 229 West 43rd St., New York, N. Y.
Victor Electric Products, Inc., 2950 Robertson Ave., Cincinnati 9, Ohio
Wallace & Tiernan Products, Inc., Belleville, N. J.
Warren Telechron Co., Ashland, Mass.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Mountings

VIBRATION INSULATING

A.B.C. Products, Inc., 11952 Montana Ave., West Los Angeles, Calif.
Barry Co., L. N., 119 Sidney St., Cambridge, Mass.
Chamberlain Laboratories, 637 Ardson Rd., E. Lansing, Mich.
Firestone Industrial Products Co., 1200 Firestone Parkway, Akron 17, Ohio
General Tire & Rubber Co., Akron, Ohio and Wabash, Ind.
Goodrich Co., B. F., 500 S. Main St., Akron, Ohio
Goodyear Tire & Rubber Co., Inc., Akron 16, Ohio
Hamilton Kent Mfg. Co. Inc., Div. U. S. Stoneware, Kent, Ohio
Harris Products Co., 5105 Cowan Ave., Cleveland, Ohio
Johns-Manville, 22 E. 40th St., New York, N. Y.
Korfund Co., Inc., 48-15 32nd Place, Long Island City, N. Y.
Lord Mfg. Co., 1635 W. 12th St., Erie, Pa.
MB Manufacturing Co., Inc., 250 Dodge Ave., East Haven 12, Conn.
Racon Electric Co., Inc., 52 E. 19th St., New York 3, N. Y.
Robinson Aviation Inc., 730 Fifth Ave., New York 19, N. Y.
Russell & Stoll Co., 125 Barclay St., New York 7, N. Y.
Sponge Rubber Co., Shelton, Conn.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Vendo Co., 1907 Grand Ave., Kansas City, 8, Mo.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Multipliers

VOLTMETER

Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Ballantine Laboratories, Inc., Boonton, N. J.
Boes Co., W. W., 3001 Salem Avenue, Dayton 3, Ohio
Burlington Instrument Corp., 214 North 4th St., Burlington, Iowa
Daven Co., 191 Central Ave., Newark 4, N. J.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 So. State St., Los Angeles 7, Calif.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Instrument Resistors Co., 25 Amity St., Little Falls, N. J.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Marion Electrical Instrument Co., Manchester, N. H.
Precision Resistor Co., 334 Badger Ave., Newark 8, N. J.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sprague Electric Co., North Adams, Mass.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

Name Plates

see Escutcheons

Needles

CUTTING

Acton Co., H. W., 370 Seventh Ave., New York, N. Y.
Audio Devices, Inc., 444 Madison Ave., New York 22, N. Y.
Capps Co., Frank L., 244 W. 49th St., New York 19, N. Y.
Diamond Tool Replacements Div., Oscap Mfg. Co., 207 W. Saratoga St., Baltimore 1, Md.
Duotone Co., 799 Broadway, New York, N. Y.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Eldeen Co., 504 N. Water St., Milwaukee, Wisc.
Electrovox Co., 169 Maplewood Ave., Maplewood, N. J.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Federal Recorder Co., Elkhart, Ind.
Galvin Mfg. Corp., 4545 W. Augusta Blvd., Chicago 51, Ill.
Garod Radio Corp., 70 Washington St., Brooklyn, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Phonograph Co., Putnam, Conn.
Gould-Moody Co., 395 Broadway, New York, N. Y.
Howard Radio Co., 1735 Belmont Ave., Chicago 13, Ill.
J. F. D. Mfg. Co., 4111 Fort Hamilton Pkway., Brooklyn, N. Y.
Memovox, Inc., 9242 Beverly Blvd., Beverly Hills, Calif.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Mirror Record Corp., 58 West 25th St., New York, N. Y.
Music Master Mfg. Co., 542 S. Dearborn St., Chicago 5, Ill.
Paraloy Co., 600 S. Michigan Ave., Chicago, Ill.
Permo Incorporated, 6415 Ravenswood Ave., Chicago, Ill.
Phonograph Needle Mfg. Co., Inc., 42 Dudley St., Providence 5, R. I.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Recordisc Corp., 395 Broadway, New York, N. Y.
Recotone Corp., 212 Fifth Ave., New York, N. Y.
Speak-O-Phone Recording & Equipment Co., 23 W. 60th St., New York, N. Y.
Wilcox Gay Corp., Charlotte, Michigan

PLAY BACK

Acton Co., H. W., 370 Seventh Ave., New York, N. Y.
Audak Co., 500 Fifth Ave., New York, N. Y.
Audio Devices Inc., 444 Madison Ave., New York 22, N. Y.
Boetsch Brothers, 221 E. 144th St., New York 51, N. Y.
Capps Co., Frank L., 244 W. 49th St., New York 19, N. Y.
Duotone Co., 799 Broadway, New York, N. Y.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Eldeen Co., 504 N. Water St., Milwaukee, Wisc.
Electrovox Co., 169 Maplewood Ave., Maplewood, N. J.
Galvin Mfg. Corp., 4545 W. Augusta Blvd., Chicago 51, Ill.
Garod Radio Corp., 70 Washington St., Brooklyn, N. Y.
Garrard Sales Corp., 401 Broadway, New York 13, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Phonograph Co., Putnam, Conn.
Gerett Corp., M. A., 724 W. Winnebago St., Milwaukee 5, Wisc.
Gould-Moody Co., 395 Broadway, New York, N. Y.
Harris Mfg. Co., 2422 W. Seventh St., Los Angeles, Calif.
Howard Radio Co., 1735 Belmont Ave., Chicago 13, Ill.
J. F. D. Mfg. Co., 4111 Fort Hamilton Pkway., Brooklyn, N. Y.
Jensen Industries, Inc., 737 N. Michigan Ave., Chicago 11, Ill.
Lowell Needle Co., 1 Wildore St., Putnam, Conn.

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ELECTRONIC and ALLIED PRODUCTS

Lux Clock Manufacturing Co., Waterbury, Conn.
Memovox, Inc., 9242 Beverly Blvd., Beverly Hills, Calif.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Mirror Record Corp., 58 W. 25th St., New York, N. Y.
Music Master Mfg. Co., 542 S. Dearborn St., Chicago 5, Ill.
Paraloy Co., 600 S. Michigan Ave., Chicago, Ill.
Permo Incorporated, 6415 Ravenswood Ave., Chicago, Ill.
Pfanstiehl Chemical Co., 104 Lakeview Ave., Waukegan, Ill.
Phonograph Needle Mfg. Co., Inc., 42 Dudley St., Providence 5, R. I.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Recotone Corp., 212 Fifth Ave., New York, N. Y.
Recordit Co., The, 555 Bedford Ave., University City, Mo.
Shure Brothers, 225 W. Huron St., Chicago, Ill.
Speak-O-Phone Recording & Equipment, 23 W. 60th St., New York, N. Y.
Stark Sound Engrg. Corp., P. O. 493, Fort Wayne 1, Ind.
Wilcox Gay Corp., Charlotte, Mich.

Nickel

see Metals

Nickel Tubing

see Tubing, Metal & Alloy

Noise Analyzers

see Analyzers

Noise Filters

see Filters

Noise Recorders

see Recorders

Nuts, Self-Locking

see Fasteners

Optical Equipment

American Lens Co., Inc., 45 Lispenard St., New York 13, N. Y.
American Optical Co., Scientific Instrument Div., Buffalo 11, N. Y.
Bausch & Lomb Optical Co., 635 St. Paul Street, Rochester 2, N. Y.
Distillation Products, Inc., 755 Ridge Rd. W., Rochester, N. Y.
Eastman Kodak Co., Rochester 4, N. Y.
Electronic Products Mfg. Co., 7300 Huron River Drive, Dexter, Mich.
Farrand Optical Co., Inc., Bronx Blvd. & East 238th St., New York 66, N. Y.
Federal Mfg. & Engrg. Corp., 199-217 Steuben St., Brooklyn, N. Y.
Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.
Gamma Instrument Co., Inc., 95 Madison Ave., New York 16, N. Y.
Herron Optical Co., 705 West Jefferson Blvd., Los Angeles 7, Calif.
Instrument Optics Co., 1872 Genesee St., Buffalo 11, N. Y.
International Industries, Inc., Ann Arbor, Mich.
Knights Co., James, 131 S. Wells St., Sandwich, Ill.
Maberg Optical, Inc., 235 East 45th St., New York 17, N. Y.
Mogey & Sons, Inc., Wm., 76 Interhaven Ave., Plainfield, N. J.
Parker Engineering Products Co., 16 W. 22nd St., New York 10, N. Y.
Perkin-Elmer Corp., Glenbrook, Conn.
Scherr, George, 128 Lafayette St., New York, N. Y.
Square D Company, 6060 Rivard St., Detroit 11, Michigan
Times Telephoto Equipment, Inc., 229 West 43rd St., New York, N. Y.
Zenith Optical Co., 123 West 64th St., New York 23, N. Y.

Oscillators

AUDIO-FREQUENCY

American Instrument Co., 8030 Georgia Ave., Silver Spring, Md.
American Radio Co., 611 E. Garfield Ave., Glendale, Calif.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Boonton Radio Corp., Boonton, N. J.
Carron Mfg. Co., 415 S. Aberdeen St., Chicago, Ill.
Clough-Brengle Co., 5501 N. Broadway, Chicago 22, Ill.
Collins Radio Co., 855-35th St., N. E., Cedar Rapids, Iowa
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Dayco Radio Corp., 915 Valley St., Dayton 4, Ohio
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electro Engineering & Mfg. Co., 627 W. Alexandrine Ave., Detroit 1, Mich.
Electro Products Laboratories, 549 W. Randolph St., Chicago, Ill.
Espey Mfg. Co., Inc., 33 West 46th St., New York, N. Y.
Fada Radio & Electric Co., 30-20 Thomson Ave., Long Island City, N. Y.
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hearing Aid Labs., 1404 Franklin St., Michigan City, Ind.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Cal.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 1, Ohio
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, L. I., N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Maico Co., Inc., 25 North 3rd St., Minneapolis 1, Minn.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Philharmonic Radio Corp., 528 East 72nd St., New York 21, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Design Co., 1353 Sterling Place, Brooklyn, N. Y.
Reiner Electronics Co., 152 W. 25th St., New York, N. Y.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Rowe Radio Research Laboratory Co., 2422 N. Pulaski Rd., Chicago 39, Ill.
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Signal Electronic & Mfg. Co., 114 East 16th St., New York 3, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Simpson Mfg. Co., Inc., Mark, 188 W. Fourth St., New York, N. Y.
Sonora Radio & Television Corp., 2626 W. Washington St., Chicago 28, Ill.
Standard Instruments Corp., 568 Prospect Ave., New York 55, N. Y.
Supreme Instruments Corp., Greenwood, Miss.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Telegraph Apparatus Co., 325 W. Huron St., Chicago, Ill.
Televiso Products, Inc., 6533 N. Olmsted Ave., Chicago, Ill.
Templetone Radio Mfg. Corp., New London, Conn.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.
Triumph Mfg. Co., 913 W. Van Buren St., Chicago 7, Ill.
United Cinephone Corp., 35 New Litchfield St., Torrington, Conn.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Western Electric Co. Inc., 120 Broadway, New York 5, N. Y.
White Research, 899 Boylston St., Boston, Mass.

RADIO-FREQUENCY

A. R. F. Products, 7627 Lake St., River Forest, Ill.
Baldwin Locomotive Works, Eddystone, Pa.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Belmont Radio Corp., 5921 Dickens Ave., Chicago, Ill.
Breon Laboratories, 607 Rose Street, Williamsport, Pa.
Burnett Radio Lab., Wm. W. L., 4814 Idaho St., San Diego, Calif.
Clough-Brengle Co., 5501 N. Broadway, Chicago 22, Ill.
Collins Radio Co., 855 35th St., N.E., Cedar Rapids, Iowa
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Crystal Research Labs., Inc., 29 Allyn St., Hartford, Conn.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Electronic Measurements Co., Red Bank, N. J.
Electronic Products Co., 111 E. Third St., Mt. Vernon, N. Y.
Electronic Winding Co., 5031 Broadway, Chicago 40, Ill.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.
Ferris Instrument Co., 110-112 Cornelia St., Boonton, N. J.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Crystal Corp., 1775 Foster Ave., Schenectady, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Intra-Therm Corp., Third & Keo Way, Des Moines 9, Iowa
Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 1, Ohio
Jefferson Inc., Ray, 40 E. Merrick Rd., Freeport, L. I., N. Y.
Lavoie Laboratories, Morganville, N. J.
Lawton Products Co., Inc., 624 Madison Ave., New York 22, N. Y.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., 61 Sherman St., Malden 48, Mass.
Pacific Electronics, Sprague at Jefferson, Spokane, Wash.
Philharmonic Radio Corp., 528 East 72nd St., New York 21, N. Y.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Premier Crystal Laboratories, Inc., 63 Park Row, New York, N. Y.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Craftsmen, 1341 So. Michigan Ave., Chicago 5, Ill.
Reiner Electronics Co., 152 West 24th St., New York, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.

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Signal Electronic & Mfg. Co., 114 East 16th Street, New York 3, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sonora Radio & Television Corp., 2626 W. Washington St., Chicago 28, Ill.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.
Standard Instruments Corp., 568 Prospect Ave., New York 55, N. Y.
Standard Piezo Co., Woolworth Bldg., Carlisle, Pa.
Supreme Instruments Corp., Greenwood, Miss.
Telegraph Apparatus Co., 325 W. Huron St., Chicago, Ill.
Televiso Products, Inc., 6533 N. Olmsted Ave., Chicago, Ill.
Templetone Radio Mfg. Corp., New London, Conn.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.
Triumph Mfg. Co., 913 W. Van Buren St., Chicago 7, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
White Research, 899 Boylston St., Boston, Mass.

Oscilloscopes

CATHODE-RAY INSTRUMENTS

Annis Co., R. B., 1101 N. Delaware St., Indianapolis 2, Ind.
Baker Chemical Co., J. T., N. Broad St., Philipsburg, N. J.
Belmont Radio Corp., 5921 Dickens Ave., Chicago, Ill.
Browning Labs., Inc., 750 Main St., Winchester, Mass.
Clough-Brengle Co., 5501 N. Broadway, Chicago 22, Ill.
Commercial Research Labs. Inc., 20 Bartlett Ave., Detroit 3, Mich.
Dayco Radio Corp., 915 Valley St., Dayton 4, Ohio
DuMont Laboratories, Inc., Allen B., 2 Main Ave., Passaic, N. J.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Grenby Mfg. Co., Plainville, Conn.
Hearing Aid Labs., 1404 Franklin St., Michigan City, Ind.
Heiland Research Corp., 130 East Fifth St., Denver 9, Colo.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Islip Radio Mfg. Corp., Foot of Beech St., Islip, New York
Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 1, Ohio
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Panoramic Radio Corp., 242 W. 55th St., New York 19, N. Y.
Philharmonic Radio Corp., 528 East 72nd St., New York 21, N. Y.
Radio City Products Co., Inc., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Reiner Electronics Co., 152 West 25th St., New York, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Signal Electronic & Mfg. Co., 114 East 16th Street, New York 3, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Standard Instruments Corp., 568 Prospect Ave., New York 55, N. Y.
Supreme Instrument Corp., Greenwood, Miss.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Templetone Radio Corp., New London, Conn.
Triumph Mfg. Co., 913 W. Van Buren St., Chicago 7, Ill.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Waugh Labs. Div. of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
White Research, 899 Boylston St., Boston, Mass.

Oscillographs

MOVING-CONDUCTOR

Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Engineering Laboratories, 602 East Fourth St., Tulsa 3, Okla.
General Electric Co., Schenectady 5, N. Y.
Geophysical Instrument Co., Key Blvd. & Nash St., Arlington, Va.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Heiland Research Corp., 130 East Fifth St., Denver 9, Colo.
Miller Corp., Wm., 362 W. Colorado St., Pasadena, Calif.
Sanborn Co., 39 Osborne St., Cambridge 39, Mass.
Waugh Labs., Div., of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.

MULTI-ELEMENT

Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Cambridge Instrument So., 3732 Grand Central Terminal, New York 17, N. Y.
Electro-Medical Laboratory, Inc., Hollis-ton, Mass.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
General Electric Co., Schenectady 5, N. Y.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Heiland Research Corp., 130 East Fifth St., Denver 9, Colo.
Metron Instrument Co., 432 Lincoln St., Denver 9, Colo.
Miller Corp., Wm., 362 W. Colorado St., Pasadena, Calif.
Sanborn Co., 39 Osborne St., Cambridge 39, Mass.
Waugh Labs., Div., of Waugh Equipment Co., 420 Lexington Ave., New York. 17, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.

PIEZOELECTRIC

Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City, Kans.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Tibbetts Laboratories, Camden, Maine
Transmitter Equipment Mfg. Co. Inc., 345 Hudson St., New York 14, N. Y.
Waugh Labs., Div., of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.

RECORDING

Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Consolidated Engineering Corp., 595 E. Colorado, Pasadena 1, Calif.
Electro Medical Lab. Inc., Holliston, Mass.
Electronic Supply Co., 207 Main St., Worcester, Mass.
General Electric Co., Schenectady 5, N. Y.
Giannini & Co., Inc., G. M., 161 E. California St., Pasadena, Calif.
Offner Electronics Inc., 5320 N. Kedzie Ave., Chicago 25, Ill.
Rahm Instruments, Inc., 12 West Broadway, New York, N. Y.
Waugh Labs., Div. of Waugh Equipment Co. 420 Lexington Ave., New York 17, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Panels

see Cabinets

Paper

see Capacitors, Fixed
see Insulation, Paper
see Tubing, Paper

Parts, Precision

Ace Mfg. Corp., 1255 E. Erie Ave., Philadelphia 24, Pa.
Teleoptic Co., 1241 Mound Ave., Racine, Wisc.
Wadsworth Watch Case Co. Inc., Dayton, Ky. (suburb of Cincinnati, Ohio)

Parts, Tube

see Tube Parts

Phonographs

ELECTRIC PHONOGRAPHS and RECORD PLAYERS

Admiral Corp., 3800 W. Cortland St., Chicago 47, Ill.
Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Ansley Radio Corp., 21-10 49th Ave., Long Island City, N. Y.
Audio Industries, Michigan City, Ind.
Autocrat Radio Co., 3855 N. Hamilton Ave., Chicago, Ill.
Bell Sound Systems, Inc., 1183 Essex Ave., Columbus, Ohio
Bendix Radio Corp., Baltimore 4, Md.
Boetsch Bros., 221 E. 144th St., New York 51, N. Y.
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Colonial Radio Corp., 254 Rano St., Buffalo 7, N. Y.
Columbia Associates, 141 West 24th St. New York, N. Y.
Connecticut Telephone & Elec. Div., Great American Industries, Meriden, Conn
Crosley Corp., 1329 Arlington St., Cincinnati 3, Ohio
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Dynavox Corp., 40-05 21st St., Long Island City, N. Y.
Electro Acoustic Co., 2131 Bueter Rd., Fort Wayne, Ind.
Electromatic Mfg. Corp., 88 University Place, New York, N. Y.
Electronic Corp. of America, 45 West 18th St., New York 11, N. Y.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Fada Radio & Electric Co., Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3702 Pontiac St., Fort Wayne, Ind.
Freed Radio Corp., 200 Hudson St., New York, N. Y.
Galvin Mfg. Corp., 4545 W. Augusta Blvd., Chicago 51, Ill.
Garod Radio Corp., 70 Washington St., Brooklyn, N. Y.
Garrard Sales Corp., 401 Broadway, New York 13, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Television & Radio Corp., 2701 North Lehmann Ct., Chicago 14, Ill.
Godfrey Mfg. Co., 171 S. 2nd St., Milwaukee 4, Wisc.
Hamilton Radio Corp., 510 Sixth Ave., New York, N. Y.
Harris Mfg. Co., 2422 W. Seventh St., Los Angeles 5, Calif.
Hearing Aid Labs., 1404 Franklin St., Michigan City, Ind.
Herbach & Rademan Co., 517 Ludlow St., Philadelphia 6, Pa.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles, Calif.
Keith Radio Products, 16th & K St., Bedford, Ind.
Magnavox Co., The, 2131 Bueter Rd., Fort Wayne 4, Ind.
Meck Industries, John, Plymouth, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.

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ELECTRONIC and ALLIED PRODUCTS

Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Memovox, Inc., 9242 Beverly Blvd., Beverly Hills, Calif.
Midwest Radio Corp., 909 Broadway, Cincinnati 2, Ohio
Mills Industries, Inc., 4100 Fullerton Ave., Chicago 39, Ill. (Coin operated).
Minerva Corp. of America, 238 William St., New York 17, N. Y.
Music Master Mfg. Co., 542 S. Dearborn St., Chicago 5, Ill.
Newcomb Audio Products Co., 2815 S. Hill St., Los Angeles 18, Calif.
Noblitt Sparks Industries, Inc., Columbus, Ind.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Pacific Sound Equipment Co., 1534 Cahuenga Blvd., Hollywood, Calif.
Philco Corp., Tioga & C Sts., Philadelphia 34, Pa.
Philharmonic Radio Corp., 528 East 72nd St., New York 24, N. Y.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Ray Energy & Television Corp. of America, 521 Fifth Ave., New York, N. Y.
Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Regal Electronics Corp., 20 West 20th St., New York, N. Y.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Rex Products Co., 1313 W. Randolph St., Chicago 7, Ill.
Robinson Recording Laboratories, 351 Ninth St., Philadelphia, Pa.
Rock-Ola Mfg. Corp., 867 N. Kedzie Ave., Chicago, Ill. (Coin Operated)
Seeburg Corp., J. P., 1510 N. Dayton St., Chicago, Ill.
Sentinel Radio Corp., 2020 Ridge Ave., Evanston, Ill.
Sheridan Electro Corp., 2850 S. Michigan Ave., Chicago, Ill.
Signal Electronic & Mfg. Co., 114 East 16th Street, New York 3, N. Y.
Simpson Mfg. Co., Inc., Mark, 188 West Fourth St., New York, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago 12, Ill.
SOS Cinema Supply Co., 449 W. 42nd St., New York 18, N. Y.
Sparkes Mfg. Co., 318 Jefferson St., Newark, N. J.
Sparks Withington Co., Jackson, Mich.
Stewart Warner Corp., 1836 Diversey Pkwy., Chicago, Ill.
Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
Symphonic Radio & Electronic Corp., 258 Park Sq. Bldg., Boston, Mass.
Talk-A-Phone Mfg. Co., 1512 S. Pulaski Road, Chicago 23, Ill.
Tech-Master Products Co., 123 Prince St., New York, N. Y.
Trav-Ler Karenola Radio & Television Corp., 571 W. Jackson Blvd., Chicago 6, Ill.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Viewtone Co., 203 East 18th St., New York, N. Y.
Waters Conley Co., 501 First St., N. W., Rochester, Minn.
Watterson Radio Mfg. Co., P. O. Box 54, Dallas, Texas
Wilcox Gay Corp., Charlotte, Mich.
Wurlitzer Mfg. Co., Rudolph, North Tonawanda, N. Y.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

Photocells

see Tubes (Phototubes & Cells)

Phototubes

see Tubes

Pickups

INDUSTRIAL PICKUPS

Audak Co., 500 Fifth Ave., New York, N. Y.
Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Consolidated Engineering Corp., 595 E. Colorado St., Pasadena 1, Calif.
Electro Products Laboratories, 549 W. Randolph St., Chicago, Ill.
Electronic Control Corp., 1573 E. Forest St., Detroit, Mich.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Giannini & Co., Inc., G. M., 161 E. California St., Pasadena, Calif.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Shure Brothers, 225 W. Huron St., Chicago, Ill.
Simpson Mfg. Co. Inc., Mark, 188 W. Fourth St., New York, N. Y.
Webster Electric Co., 1900 Clark St., Racine, Wisc.

PHONOGRAPH PICKUPS

Aray Mfg. & Supply Co., Inc., 3107 Pine St., St. Louis 3, Mo.
Astatic Corp., Conneaut, Ohio
Audak Co., 500 Fifth Ave., New York, N. Y.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Boetsch Bros., 221 E. 144th St., New York 51, N. Y.
Garrard Sales Corp., 401 Broadway, New York 13, N. Y.
General Electric Co., Schenectady 5, N. Y.
Miller Corp., Wm., 362 W. Colorado St., Pasadena, Calif.
Pacific Sound Equipment Co., 1534 Cahuenga Blvd., Hollywood, Calif.
Pfanstiehl Chemical Co., 104 Lakeview Ave., Waukegan, Ill.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rek-O-Kut Co., 173 Lafayette St., New York 13, N. Y.
Shure Brothers, 225 W. Huron St., Chicago, Ill.
Techno Scientific Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
Tibbetts Laboratories, Camden, Maine
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Webster Electric Co., 1900 Clark St., Racine, Wisc.

Pilot Lights

see Lights

Plastics

FABRICATORS of PLASTICS

Acadia Synthetic Products Div., Western Felt Works, 4035 Ogden Ave., Chicago 23, Ill.
Accurate Molding Corp., 116 Nassau St., Brooklyn 1, N. Y.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Insulator Corp., New Freedom, Pa.
American Molded Products Co., 1751 N. Honore St., Chicago, Ill.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
Anchor Plastics Co., 533-41 Canal St., New York 13, N. Y.
Atlas Products Corp., 30 Rockefeller Plaza, New York 20, N. Y.
Auburn Button Works, Inc., 48 Canoga St., Auburn, N. Y.
Baer Co., N. S., 9 Montgomery St., Hillside, N. J.
Biwax Corp., 3445 Howard St., Skokie, Ill.
Boonton Molding Co., Boonton, N. J.
Brach Mfg. Corp., L. S., 55 Dickerson St., Newark, N. J.
Breeze Corp., 41 S. Sixth St., Newark, N. J.
Bridgeport Molded Products, Inc., 303 Myrtle Ave., Bridgeport, Conn.
Brilhart Ltd., Arnold, 435 Middle Neck Rd., Great Neck, L. I., New York
Celluplastic Corp., 50 Avenue L, Newark 5, N. J.
Chicago Molded Products Corp., 1020 N. Kolmar Ave., Chicago 51, Ill.
Cincinnati Molding Co., 2037 Florence Ave., Cincinnati 6, Ohio
Cleveland Plastics, Inc., 1611 East 21st St., Cleveland 14, Ohio
Colt's Patent Fire Arms Mfg. Co., Plastics Div., Hartford, Conn.
Consolidated Molded Products Corp., 309 Cherry St., Scranton 2, Pa.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Cutler-Hammer Inc., 315 North 12th St., Milwaukee 1, Wisc.
Davies Molding Co., Harry, 1428 N. Wells St., Chicago 10, Ill.
Davis Plastics Co., Joseph, Arlington, N. J.
Diemolding Corp., Rasbach St., Canastota, N. Y.
Dimco Plastics, 207 E. 6th St., Dayton, Ohio
Eagle Electric Mfg. Co., Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Eagle Plastics Corp., 23-10 Bridge Plaza So., Long Island City, N. Y.
Eclipse Moulded Products Co., 5151 North 32nd St., Milwaukee 9, Wis.
Electric Auto-Lite Co., Toledo 1, Ohio
Electrical Insulation Co., 12 Vestry St., New York, N. Y.
Electronic Products Co., 19 North First St., Geneva, Ill.
Emeloid Co., 291 Laurel Ave., Arlington, N. J.
Erie Resistor Corp., 644 W. 12th St., Erie, Pa.
Felsenthal & Sons, G., 4122 W. Grand Ave., Chicago 51, Ill.
Formica Insulation Co., 4662 Spring Grove Ave., Cincinnati, Ohio
Franklin Fibre-Lamitex Corp., 12th & French Sts., Wilmington, Del.
Franklin Mfg. Corp., A. W., 175 Varick St., New York 14, N. Y.
Garfield Mfg. Co., Garfield, N. J.
Gemloid Corp., 79-10 Albion Ave., Elmhurst, L. I., N. Y.
General Electric Co., Plastics Div., 1, Plastics Ave., Pittsfield, Mass.
General Laminated Products, Inc., 175 Varick St., New York, N. Y.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Hopp Press, Inc., 460 W. 34th St., New York, N. Y.
House of Plastics, 1720 Euclid Ave., Cleveland 15, Ohio
Howard Plastics, Inc., 2600 Grand Ave., Kansas City 8, Mo.
Imperial Molded Products Corp., 2925 W. Harrison St., Chicago, Ill.
Industrial Synthetics Corp., 60 Woolsey St., Irvington, N. J.
Insulating Fabricators Inc., 12 East 12th St., New York 3, N. Y.
Insulating Fabricators of New England, Inc., 22 Elkins St., S. Boston, Mass.
Insulation Mfg. Co., 11 New York Ave., Brooklyn, N. Y.
Insulation Products Co., 504 Richland St., Pittsburgh, Pa.
International Products Corp., Baltimore 18, Md.
Jorgensen Mfg. Co., 1547 West Farms Rd., New York 60, N. Y.
Keystone Specialty Co., 1372½ Cove Ave., Cleveland, Ohio
Kirk Molding Co., F. J., 142 Brook St., Clinton, Mass.
Knoedler Co., A., Lancaster, Pa.
Kuhn & Jacob Moulding & Tool So., 1200 Southard St., Trenton, N. J.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Kurz-Kasch Co., 1415 S. Broadway, Dayton 1, Ohio
Lacey-Webber Co., Kalamazoo, Mich.
Lamicoid Fabricators, 3600 W. Potomac Ave., Chicago, Ill.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Mills Corp., Elmer, E., 812 W. Van Buren St., Chicago, Ill.
Molded Insulation Co., Aircraft Control Div., 335 E. Price St., Philadelphia, Pa.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
National Fabricated Products, 2650 Belden Avenue, Chicago 47, Ill.

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Northern Industrial Chemical Co., 7-11 Elkins St. South Boston 27, Mass.
Northwest Plastics, Inc., 2333 University Ave., St. Paul 4, Minn.
Norton Laboratories, 520 Mill St., Lockport, N. Y.
Panelyte Div., St. Regis Paper Co., 230 Park Ave., New York 17, N. Y.
Parisian Novelty Co., 3510 S. Western Ave., Chicago 9, Ill.
Parker Engineering Prods. Co., 16 West 22nd St., New York 10, N. Y.
Patent Button Co. of Tenn., Inc., 2221 Century St., Knoxville 8, Tenn.
Plastic Manufacturers, Inc., Stamford, Conn.
Plax Corp., 133 Walnut St., Hartford, 5, Conn.
Poinsetta, Inc., 95 Cedar Ave., Pitman, N. J.
Precision Fabricators, Inc., Rochester, N. Y.
Printloid, Inc., 95 Mercer St., New York 12, N. Y.
R. E. C. Mfg. Corp., 1250 Highland St., Holliston, Mass.
Recto Molded Products, Appleton St. & B. & O. R. R., Cincinnati, Ohio
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif.
Resinous Products & Chemical Co., 222 W. Washington Sq., Philadelphia, Pa.
Resistoflex Corp., Belleville 9, N. J.
Reynolds Spring Co., Molded Plastics Div., Reynolds Bldg., Jackson, Mich.
Richardson Co., Melrose Park, Ill.
Rogan Brothers, 2001 S. Michigan Ave., Chicago, Ill.
Rohm & Haas, 222 W. Washington Sq., Philadelphia, Pa.
Royal Moulding Co., 69 Gordon Ave., Providence 5, R. I.
Santay Corporation, 351 N. Crawford Ave., Chicago 24, Ill.
Sillcocks-Miller Co., 10 Parker Ave., W. South Orange, N. J.
Standard Molding Corp., Dayton, Ohio
Standard Product Co., 505 Boulevard Bldg., Detroit 2, Mich.
Stokes Rubber Co., Jos. Taylor & Webster Sts., Trenton, N. J.
Synthetic Plastics Co., 88 St. Francis St., Newark, N. J.
Syracuse Ornamental Co., 581 So. Clinton St., Syracuse, N. Y.
Talking Devices Co., 4447 W. Irving Park Rd., Chicago, Ill.
Tech-Art Plastics Co., 41-01 36th Ave., Long Island City 1, N. Y.
Technical Plastics Co., 618 Clyde St., Pittsburgh 13, Pa.
Tri-United Plastics Corp., 390 Nye Ave., Irvington, N. J.
Tungsten Contact Mfg. Co., North Bergen, N. J.
Universal Plastics Corp., 235 Jersey Ave., New Brunswick, N. J.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Varflex Corp., N. Jay St., Rome, N. Y.
Victory Manufacturing Co., 1722 W. Arcade Place, Chicago 12, Ill.
Waterbury Companies, Inc., 835 Main St., Waterbury, Conn.
Watertown Mfg. Co., Watertown, Conn.
Werner Co. Inc., R. D., 295 Fifth Avenue, New York 16, N. Y.
Western Felt Works, 4029 Ogden Ave., Chicago, Ill.
Western Lithograph Co., 2nd St., Los Angeles, Calif.
Westinghouse Elec. Corp., East Pittsburgh, Pa.
White Dental Mfg. Co., S. S., Industrial Division, 10 East 40th St., New York, N. Y.
Willor Mfg. Corp., 794 East 140th St., New York 54, N. Y.
Windman Bros., 3325 Union Pacific Ave., Los Angeles 23, Calif.
Worcester Moulded Plastics Co., 8 Grafton St., Worcester 8, Mass.

MANUFACTURERS of PLASTICS

American Cyanamid Co., Plastics Div., 30 Rockefeller Plaza, New York 20, N. Y.
American Phenolic Corp., 1830 S. 54th Ave., Chicago, Ill.
Bakelite Corp., 30 E. 42nd St., New York 17, N. Y.
Carbide & Carbon Chemicals Corp., 30 E. 42nd St., New York, N. Y.
Catalin Corp., 1 Park Ave., New York, N. Y.
Celanese Plastics Corp., 180 Madison Ave., New York 16, N. Y.
Ciba Co., Inc., 627 Greenwich St., New York 14, N. Y.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Dow Chemical Co., Midland, Mich.
duPont de Nemours & Co., Inc., E. I., Wilmington 98, Del.
Durez Plastics & Chemicals, Inc., 1922 Walck Rd., North Tonawanda, N. Y.
Durite Plastics, Inc., 5010 Summerdale Ave., Philadelphia 24, Pa.
Eastman Kodak Co., Rochester 4, N. Y.
General Electric Co., Plastics Div., 1, Plastics Ave., Pittsfield, Mass.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Industrial Synthetics Corp., 60 Woolsey St., Irvington, N. J.
Interlake Chemical Corp., Union Commerce Bldg., Cleveland 14, Ohio
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Makalot Corp., 262 Washington St., Boston, Mass.
Marblette Corp., 37-21 30th St., Long Island City 1, N. Y.
Mica Insulator Co., 200 Varick St., New York 14, N. Y.
Monsanto Chemical Co., Plastics Div., Springfield 2, Mass.
National Vulcanized Fibre Co., Maryland Ave., Wilmington, Del.
Nixon Nitration Works, Nixon, N. J.
Panelyte Div., St. Regis Paper Co., 230 Park Ave., New York, N. Y.
Plaskon Div., Libbey-Owens-Ford-Glass Co., 2112 Sylvan Ave., Toledo 6, Ohio
Plax Corp., 133 Walnut St., Hartford 5, Conn.
Poinsetta, Inc., 95 Cedar St., Pitman, N. J.
Reilly Tar & Chemical Corp., Merchants Bank Bldg., Indianapolis, Ind.
Respro, Inc., Wellington Ave., Cranston, R. I.
Richardson Co., Melrose Park, Ill.
Rogers Paper Mfg. Co., Manchester, Conn.
Rohm & Haas, 222 Washington Sq., Philadelphia 5, Pa.
Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N. Y.
Synthane Corp., Oaks, Pa.
Taylor Fibre Co., Norristown, Pa.
Tennessee Eastman Corp., Kingsport, Tenn.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Plastics and Metal Marking Machines & Stencils

Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
Annis Co., R. B., 1101 N. Delaware St., Indianapolis 2, Ind.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Austin Co., O., 42 Greene St., New York, N. Y.
Auto Engraver Co., 1776 Broadway, New York, N. Y.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Bastian Bros. Co., 1660 N. Clinton Ave., Rochester, N. Y.
Bemer Bros. Engraving Co., 103 Lafayette St., New York, N. Y.
Burndy Engrg. Co., 107 Bruckner Blvd., New York 54, N. Y.
Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
Eastern Etching & Mfg. Co., Chicopee, Mass.
Edwards, Inc., J. T., 121 Beach St., Boston 5, Mass.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb.
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.
Leiman Bros., 203 Christie St., Newark, 5, N. J.
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton 5, N. J.
Long Island Engraving Co., 19 West 21st St., New York 10, N. Y.
Markem Machine Co., Keene, N. H.
Micarta Fabricators, Inc., 5324 Ravenswood Ave., Chicago 40, Ill.
Mico Instrument Co., 80 Trowbridge St., Cambridge 38, Mass.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
New Method Steel Stamps, Inc., 149 Joseph Campau Ave., Detroit 7, Mich.
Numberall Stamp & Tool Co., 379 Huguenot Ave., Huguenot Park, Staten Island 12, N. Y.
Parisian Novelty Co., 3510 S. Western Ave., Chicago 9, Ill.
Plastic Fabricators Co., 440 Sansome St., San Francisco 11, Calif.
Preis Engraving Machine Co., H. P., 155 Summit St., Newark 4, N. J.
Rogan Bros., 2001 S. Michigan Ave., Chicago, Ill.
Screenmakers, 64 Fulton St., New York 1, N. Y.
Sparkes Mfg. Co., 318 Jefferson St., Newark, N. J.

Plastic Insulation

see Insulation, Plastic

Plating, Metal, on Plastics

Airplane & Marine Instruments, Inc., Clearfield, Pa.
Aluminum Finishing Corp., 1119 E. 22nd St., Indianapolis, Ind.
Austin Co., O., 42 Greene St., New York, N. Y.
Diamond Tool Replacements Div., Oscap Mfg. Co., 207 W. Saratoga St., Baltimore 1, Md.
Distillation Products, Inc., 755 Ridge Road W., Rochester, N. Y.
Electro Plastic Processes, 2035 West Charleston St., Chicago 47, Ill.
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton 5, N. J.
Metaplast Company, 205 West 19th Street, New York 11, N. Y.
Monroe Auto Equipment Co., Monroe, Michigan
Na Mac Products Co., 1027 N. Seward Street, Los Angeles 38, Calif.
Pacific Plastic & Mfg. Co., Inc., 4865 Exposition Blvd., Los Angeles 16, Calif.
Philadelphia Rust-Proof Co., 3229 Frankford Ave., Philadelphia 34, Pa.
Sievering, Inc., Philip, 199 Lafayette Street, New York, N. Y.

Players, Record

see Phonographs

Plugs

TERMINAL PLUGS

see also Jacks

Airadio, Inc., Melrose Ave. & Battery Place, Stamford, Conn.
Aircraft-Marine Prods., Inc., 1523 N. Fourth, St. Harrisburg, Pa.
Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
Aircraft Radio Corp., Boonton, N. J.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
Amalgamated Radio & Television Corp., 476 Broadway, New York 13, N. Y.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway. St., Mt. Vernon, N. Y.
Atlas Products Corp., 30 Rockefeller Plaza, New York, N. Y.
Audio Development Co., 2833 13th Ave. S., Minneapolis 7, Minn.
Automatic Electric Co., 1033 West Van Buren St., Chicago 7, Ill.
Automatic Metal Products Corp., 315 Berry St., Brooklyn, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Brach Co., L. S., 55 Dickerson St., Newark 4, N. J.
Breeze Corp., 41 South Sixth St., Newark, N. J.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Burndy Engrg. Co., 107 Bruckner Blvd., New York 54, N. Y.
Cinch Mfg. Corp., 2335 W. Van Buren St., Chicago, Ill.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.

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ELECTRONIC and ALLIED PRODUCTS

Communication Measurements Laboratory, 120 Greenwich St., New York, N. Y.
Connecticut Telephone & Electric Div., Great American Industries, Inc., 70 Britannia St., Meriden, Conn.
Connector Div., International Resistance Co., 401 North Broad St., Philadelphia 8, Pa.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Eagle Electric Mfg. Co., Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Eby, Inc., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Electrix Corp., 158 Middle St., Pawtucket, R. I.
Federal Mfg. & Engrg., Corp., 199 Steuben St., Brooklyn, N. Y.
Franklin Mfg. Corp., A. W., 175 Varick St., New York, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
General Electronics Mfg. Co., 2225 S. Hoover St., Los Angeles 7, Calif.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Heinze Electric Co., Lowell, Mass.
Hubbell Inc., Harvey, Bridgeport 2, Conn.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
J. F. D. Mfg. Co., 4111 Fort Hamilton Pkway., Brooklyn, N. Y.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2460 W. George St., Chicago 18, Ill.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
National Electronic Mfg. Corp., 22-78 Steinway Street, Long Island City 5, N. Y.
North Electric Mfg. Co., 501 S. Market St., Galion, Ohio
Northam Warren Corp., Stamford, Conn.
Northwest Plastics, Inc., 2333 University Ave., St. Paul 4, Minn.
Pass & Seymour, Inc., Solvay Station, Syracuse, N. Y.
Philmore Mfg. Co., 113 University Place New York, N. Y.
Precision Specialties, 220 No. Western Ave., Los Angeles, Calif.
Pyle-National Co., 1334 N. Kostner Ave., Chicago 51, Ill.
Remler Company, Ltd., 2101 Bryant Street San Francisco, Cal.
Russell & Stoll Co., 125 Barclay St., New York 7, N. Y.
Selector Mfg. Corp., 21-10 49th Ave., Long Island City, N. Y.
Sorenz Mfg. Corp., 1901 Clybourn Ave., Chicago 14, Ill.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Standard Winding Co., 44-62 Johnes St., Newburgh, N. Y.
Telephonics Corp., 350 West 31st St., New York, N. Y.
Trav-Ler Karenola Radio & Television Corp., 571 W. Jackson Blvd., Chicago, Ill.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambrdge 42, Mass.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Whittaker Cable Corp., North Kansas City, Mo.
Willows Mfg. Corp., 341 39th St., Brooklyn, N. Y.
Wood Electric Co., Inc., C. D., 826 Broadway, New York 3, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

Pointers

DIAL POINTERS

see also Knobs
also Dials

American Brass Co., Waterbury 88, Conn.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway. S., Mt. Vernon, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bastian Bros. Co., 1600 N. Clinton Ave., Rochester, N. Y.
Birbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Bud Radio, Inc., 2118 East 55th St., Cleveland 3, Ohio
Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
Eclipse Moulded Products Co., 5151 North 32nd St., Milwaukee 9, Wis.
Felsenthal & Sons, G., 4122 W. Grand Ave., Chicago 51, Ill.
General Electric Co., Schenectady 5, N. Y.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Grammes & Sons, Inc., L. F., 389 Union St., Allentown 2, Pa.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Kurz-Kasch Co., 1415 S. Broadway, Dayton 1, Ohio
National Co., 61 Sherman St., Malden 48, Mass.
New England Radiocrafters, 1156 Commonwealth Ave., Boston 34, Mass.
Parisian Novelty Co., 3510 S. Western Ave., Chicago 9, Ill.
Plastic Fabricators, Inc., 440 Sansome St., San Francisco 11, Calif.
Printloid, Inc., 95 Mercer St., New York 12, N. Y.
Radio City Products Co., 127 West 26th St., New York, N. Y.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Victory Mfg. Co., 1722 W. Arcade Place, Chicago 2, Ill.
Winn Sons, J. H., Winchester, Mass.
Worcester Moulded Plastics Co., 8 Grafton St., Worcester 8, Mass.

Points

CONTACT POINTS and ASSEMBLIES

American Platinum Works, New Jersey R. R. Ave. at Oliver St., Newark 5, N. J.
Baker & Co., 113 Astor St., Newark 5, N. J.
Bead Chain Mfg. Co., 110 Mt. Grove St., Bridgeport 5, Conn.
Bishop & Co., Platinum Works, J., 12 Channing Ave., Malvern, Pa.
Brainin Co., C. S., 233 Spring St., New York 13, N. Y.
Callite Tungsten Corp., 544 39th St., Union City, N. J.
Cleveland Tungsten, Inc., 10200 Meech Ave., Cleveland, Ohio
Fansteel Metallurgical Corp., 2200 Sheridan Rd., North Chicago, Ill.
General Plate Div., Metals & Controls Corp., 34 Forest St., Attleboro, Mass.
General Tungsten Mfg. Co., 502 23d St., Union City, N. J.
Gibson Electric Co., 8350 Frankstown Ave., Pittsburgh 21, Pa.
Graphite Metallizing Corp., 1055 Nepperhan Ave., Yonkers 3, N. Y.
Goldsmith Bros. Smelting & Refining Co., 58 East Washington St., Chicago, Ill.
Independent Contact Mfg. Co., 540 39th St., Union City, N. J.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt Vernon, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Metroloy Co., 57 E. Alpine St., Newark, N. J.
National Carbon Co., Inc., 30 East 42nd St., New York 17, N. Y.
Noble Co., F. H., 535 West 59th St., Chicago, Ill.
Progressive Mfg. Co., 52 Norwood St., Torrington, Conn.
Speer Carbon Co., St. Marys, Pa.
Tricon Manufacturing Co., 8310 S. Racine Ave., Chicago, Ill.
Tubular Rivet & Stud Co., Wollaston 70, Mass.
Tungsten Contact Mfg. Co., North Bergen, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wilson Co., H. A., 105 Chestnut St., Newark 5, N. J.

Porcelain

see Insulation—Ceramic

Posts

BINDING POSTS and TERMINALS

Aircraft-Marine Prods. Inc., 1523 North Fourth St., Harrisburg, Pa.
Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
Aircraft Radio Corp., Boonton, N. J.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Brass Co., Waterbury 88, Conn.
American Insulator Corp., New Freedom, Pa.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway, S., Mt. Vernon, N. Y.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Atlas Products Corp., 30 Rockefeller Plaza, New York 20, N. Y.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Baer Co., N. S., 9 Montgomery St., Hillside, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bead Chain Mfg. Co., 110 Mt. Grove St., Bridgeport 5, Conn.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Brach Mfg. Corp., L. S., 55 Dickerson St., Newark, N. J.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Burke Electric Co., 12th & Cranberry Sts., Erie, Pa.
Burndy Engineering Co., Inc., 107 Bruckner Blvd., New York 54, N. Y.
Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Cinch Mfg. Corp., 2335 W. Van Buren St., Chicago, Ill.
Cinema Engineering Co., 1508 W. Verdugo Ave., Burbank, Calif.
Comar Electric Co., 3150 N. Washtenaw Ave., Chicago 28, Ill.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Curtis Development & Mfg. Co., 1 N. Crawford Ave., Chicago 24, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Eby, Inc., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Franklin Mfg. Corp., A. W., 175 Varick St., New York, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Guided Radio Corp., 161 Sixth Ave., New York 13, N. Y.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Insulation Mfg. Co., 11 New York Ave., Bklyn., N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Jones, Howard B., 2460 W. George St., Chicago 18, Ill.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kings Electronics Co., 372 Classon Ave., Brooklyn 5, N. Y.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
McInerney Plastics Co., 655 Godfrey Ave., S. W., Grand Rapids 1, Mich.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Miller Co., J. W., 5917 S. Main St., Los Angeles, Calif.
National Co., 61 Sherman St., Malden 48, Mass.
National Fabricated Products, 2650 Belden Ave., Chicago 47, Ill.

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National Vulcanized Fibre Co., Maryland Ave., Wilmington, Del.
Northern Industrial Chemical Co., 7-11 Elkins St., South Boston 27, Mass.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Plastic Manufacturers, Stamford, Conn.
Precision Specialties, 220 No. Western Ave., Los Angeles, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Sorenz Manufacturing Corp., 1901 Clybourn Ave., Chicago 14, Ill.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
States Co., 19 New Park Ave., Hartford 6, Conn.
Taylor Fibre Co., Norristown, Pa.
Templetone Radio Mfg. Corp., New London, Conn.
Thomas & Betts Co., Inc., 36 Butler St., Elizabeth 1, N. J.
Thwing-Albert Instrument Co., Penn St., & Pulaski Ave., Philadelphia 44, Pa.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Waterbury Companes, Inc., 835 S. Main St., Waterbury, Conn.
Wood Electric Co., Inc., C. D., 826 Broadway, New York 3, N. Y.

Potentiometers

see Variable Resistors

Pots, Soldering

Acme Electric Heating Co., 1217 Washington St., Boston 18, Mass.
Adams, Inc., Carman, 15476 James Couzens Highway, Detroit, Mich.
Drake Electric Works, Inc., 3656 Lincoln Ave., Chicago 13, Ill.
Electric Soldering Iron Co., 1845 W. Elm St., Deep River, Conn.
Falls Electric Furnace Corp., 660 Grant St., Buffalo, N. Y.
General Electric Co., Schenectady 5, N. Y.
Kentworthy, Inc., Charles F., 195 Piedmont St., Waterbury 23, Conn.
Lectrohm, Inc., 5141 W. 25th St., Cicero 50, Ill
Lydon Brothers, 229 Colden St., Jersey City, N. J.
Newton Junior Corp., 682 Third Ave., West Haven, Conn.
Russell Electric Co., 340 W. Huron St., Chicago, Ill.
Sta-Warm Electric Co., N. Chestnut St., Ravenna, Ohio
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia, Pa.
Trent Co., Harold E., Leverington Ave. at Wilde St., Philadelphia 27, Pa.
Vasco Electrical Mfg. Co., 4116 Avalon Blvd., Los Angeles, Calif.
Vulcan Electric Co., Danvers, Mass.
Waage Electric Co., A. H., 54 Park Place, New York 7, N. Y.
Westinghouse Electric Corp., E. Pittsburgh, Pa.
Wiegand Co., Edwin L., 7544 Thomas Blvd., Pittsburgh 8, Pa.

Power Cord

see Wire

Power Plants

see Generators

Power Supplies

Altec Lansing Corp., 1680 N. Vine St., Los Angeles 28, Calif.
American Radio Co., 611 E. Garfield Ave., Glendale, Calif.
American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
American Transformer Co., 178 Emmet St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Benwood Linze Co., 1815 Locust St., St. Louis, Mo.
Browning Labs., Inc., 750 Main St., Winchester, Mass.
Carter Motor Co., 1606 Milwaukee Ave., Chicago 47, Ill.
Communications Equipment Corp., 134 West Colorado St., Pasadena 1, Calif.
Communication Measurements Laboratory, 120 Greenwich St., New York, N. Y.
Consolidated Engineering Corp., 595 E. Colorado St., Pasadena 1, Calif.
Daven Co., 191 Central Ave., Newark 4, N. J.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electro Engineering & Mfg. Co., 627 W. Alexandrine Ave., Detroit 1, Mich.
Electro Products Laboratories, 549 W. Randolph St., Chicago, Ill.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Corp. of America, 45 West 18th St., New York 11, N. Y.
Electronic Laboratories, Inc., Indianapolis, Ind.
Electronic Products Co., 19 North First St., Geneva, Ill.
Electronic Supply Co., 207 Main St., Worcester, Mass.
Espey Mfg. Co., 33 West 46th St., New York 19, N. Y.
Fisher Research Laboratory, 1961 University Ave., Palo Alto, Calif.
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
General Transformer Corp., 1250 W. Van Buren St., Chicago 7, Ill.
Green Electric Co., Inc., W., 130 Cedar St., New York 6, N. Y.
Hamilton Radio Corp., 510 Sixth Ave., New York, N. Y.
Harvey Radio Laboratories, Inc., 447 Concord Ave., Cambridge, Mass.
Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Heath Co., Benton Harbor, Mich.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
International Transformer Co., 396 Broadway, New York, N. Y.
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, L. I., N. Y.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Lear, Inc., Piqua, Ohio
Mallory & Co., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Mellaphone Corp., Rochester 2, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
National Co., 61 Sherman St., Malden 48, Mass.
Newcomb Audio Products Co., 2815 S. Hill St., Los Angeles 18, Calif.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Philharmonic Radio Corp., 528 E. 72nd St., New York
Press Wireless, Inc., 1475 Broadway, New York, N. Y.
Radiart Corp., 3571 West 62nd St., Cleveland, Ohio
Radio Mfg. Engineers, Inc., 304 First Ave., Peoria, Ill.
Radio-Television Institute, Inc., 480 Lexington Ave., New York 17, N. Y.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Schuttig & Co., 9th & Kearney Sts., N. E., Washington 17, D. C.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Simpson Mfg. Co., Inc., Mark, 188 W. Fourth St., New York, N. Y.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Techno-Scientific Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Ward Leonard Electric Co., Mount Vernon, N. Y.
Waugh Labs., Div. of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago 47, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wilcox Electric Co., 1400 Chestnut St., Kansas City, Mo.

Powdered Metal Products

see Metals

Public Address Systems

see Sound

Pumps

VACUUM PUMPS

Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kans.
Allis Chalmers Mfg. Co., Milwaukee 1, Wis.
Central Scientific Co., 1700 Irving Park Blvd., Chicago 13, Ill.
Distillation Products, Inc., 755 Ridge Rd W., Rochester, N. Y.
Eastern Engineering Co., 45 Fox St., New Haven, Conn.
Eastman Kodak Co., Rochester 4, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Eisler Engrg. Co., 740 S. 13th St., Newark 3, N. J.
Eitel-McCullough, Inc., San Bruno, Calif.
General Electric Co., Schenectady 5, N. Y.
Haydu Bros., Mt. Bethel Rd., Plainfield, N. J.
International Machine Works, 2207 46th St. North Bergen, N. J.
Kahle Engineering Co., 1307 Seventh St., North Bergen, N. J.
Kinney Mfg. Co., 3529 Washington St. Boston, Mass.
Kraissl Co., Inc., 303 Williams Ave., Hackensack, N. J.
Leiman Bros., 203 Christie St., Newark 5, N. J.
Litton Engineering Labs., P. O. Box 749, Redwood City, Calif.
McIntyre Co., 15 Riverdale Ave., Newton, Mass.
Machlett & Son, E., 220 East 23rd St., New York 10, N. Y.
National Research Corp., Vacuum Engrg Div., 100 Brookline Ave., Boston 15, Mass.
Nelson Vacuum Pump Co., Geo. F., 2132 Fourth St., Berkeley 2, Calif.
New Jersey Machine Corp., 16th & Willow Ave., Hoboken, N. J.
Robbins & Myers, Inc., 1345 Lagonda Ave., Springfield, Ohio
Stokes Machine Co., F. J., 5850 Tabor Rd., Olney P. O., Philadelphia 20, Pa.
Sullivan Machinery Co., 929 Woodland Ave., Michigan City, Ind.
Technical Products Co., 158 Madison Ave at Third St., Memphis, Tenn.
Universal X-Ray Products Inc., 1600 North Francisco Ave., Chicago 47, Ill.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Worthington Pump & Machinery Corp. Harrison, N. J.
Yeomans Bros. Co., 1433 N. Dayton St., Chicago, Ill.

"Q" Meters

see Meters

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ELECTRONIC and ALLIED PRODUCTS

Racks, Relay

Armature Coil Equipment, Inc., 2605 Vega Ave., Cleveland 3, Ohio
Automatic Electric Co., 1033 West Van Buren St., Chicago 7, Ill.
Barker & Williamson, Upper Darby, Pa.
Cinema Engineering Co., 1508 N. Verdugo Ave., Burbank, Calif.
Communications Equipment Corp., 134 West Colorado St., Pasadena 1, Calif.
Corry Jamestown Mfg. Corp., Corry, Pa.
Dahlstrom Metallic Door Co., Buffalo St., Jamestown, New York
Falstrom Co., 7 Falstrom Court, Passaic, New Jersey
Hadley Co., Robert M., 711 East 61st St., Los Angeles, Calif.
Hudson American Corp., 25 West 43rd St., New York, N. Y.
Karp Metal Products Co., Inc., 129 Thirtieth St., Brooklyn, N. Y.
National Co., Malden 48, Mass.
Par Metal Products Corp., 32-62 49th St., Long Island City, N. Y.
Plax Corporation, 133 Walnut St., Hartford 5, Conn.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.

Radar, Complete Equipment

(INCLUDING I.F.F. AND RADAR BEACONS

Admiral Corp., 3800 W. Cortland St., Chicago, Ill.
Airadio, Inc., Barry Place, Stamford, Conn.
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago, Ill.
Bendix Radio, Div. of Bendix Aviation Corp., Baltimore, Md.
Crosley Corp., 1329 Arlington St., Cincinnati 25, Ohio
Du Mont Laboratories, Inc., Allen B., 2 Main Ave., Passaic, N. J.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Fada Radio & Electric Co., Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Fairchild Camera & Instrument Corp., 475 Tenth Ave., New York 18, N. Y.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago 51, Ill.
General Electric Co., 1 River Road, Schenectady 5, N. Y.
General Motors Corp., Detroit, Mich.
Gilfillan Bros., Inc., 1815 Venice Blvd., Los Angeles, Calif.
Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Harvey Radio Labortories, Inc., 447 Concord Ave., Cambridge, Mass.
Hazeltine Electronics Corp., 1775 Broadway, New York, N. Y.
Pacific Electronics, Sprague at Jefferson, Spokane, Wash.
Philco Corp., Ontario & C Sts., Philadelphia, Pa.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Engineering Laboratories, Inc., 35-54 36th St., Long Island City, N. Y.
Radio Mfg. Engineers, Inc., 304 First Ave., Peoria, Ill.
Radio Receptor Co., 251 W. 19th St., New York, N. Y.
Raytheon Manufacturing Co., 190 Willow St., Waltham, Mass.
Sparks-Withington Co., North St., Jackson, Mich.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn, N. Y.
Stewart-Warner Corp., 1826 Diversey Parkway, Chicago, Ill.
Stromberg-Carlson Co., 100 Carlson Road, Rochester, N. Y.
Submarine Signal Co., 160 State, Boston, Mass.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York, N. Y.
Western Electric Co., Inc., 120 Broadway, New York, N. Y.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

Receivers, Home—AM

AM COMBINATIONS

Admiral Corporation, 3800 W. Cortland St., Chicago, Ill.
Air-King Products Co., Inc., 1523-63rd St., Bklyn, N. Y.
Ansley Radio Corp., 21-10 49th Avenue, Long Island City, N. Y.
Automatic Radio Mfg. Co. Inc., 122 Brookline Avenue, Boston, Mass.
Belmont Radio Corporation, 5921 West Dickens Avenue, Chicago 39, Ill.
Bendix Radio Corp., Baltimore 4, Md.
Colonial Radio Corp., 254 Rano Street, Buffalo, N. Y.
The Crosley Corporation, Cincinnati 25, Ohio
Delco Radio Division, General Motors Corporation, Kokomo, Indiana
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Dynavox Corporation, 40-05 21st St., Long Island City, N. Y.
Echophone Radio, Div. of Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Electrical Research & Mfg. Co., 3001 E. Pico Blvd., Los Angeles, Calif.
Electromatic Mfg. Corp., 88 University Place, New York, N. Y.
Electronic Corp. of America, 45 West 18th St., New York, N. Y.
Espey Mfg. Co. Inc., 33 West 46th St., New York, N. Y.
Fada Radio & Electric Co. Inc., 30-20 Thomson Avenue, Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
Garod Radio Corp., 70 Washington St., Bklyn, N. Y.
General Electric Company, Bridgeport, Conn.
General Television & Radio Corp., 2701 North Lehmann Court, Chicago 14, Ill.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Hamilton Radio Corp., 510 Sixth Avenue, New York, N. Y.
Herbach & Rademan Co., 517 Ludlow St., Philadelphia 6, Pa.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles, Calif.
Howard Radio Co., 1731 Belmont Ave., Chicago, Ill.
International Detrola Corp., 1501 Beard Avenue, Detroit, Michigan
Keith Radio Products, 16th & K St., Bedford, Ind.
Kingston Products Corp., Kokomo, Indiana
Lear, Inc., Piqua, Ohio
Magnavox Company, 2131 Bueter Road, Fort Wayne, Indiana
Majestic Radio & Television Corp., St. Charles, Ill.
Meck Industries, John, Liberty at Pennsylvania, Plymouth, Ind.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Megard Corporation, 1601 S. Burlington Avenue, Los Angeles 6, Calif.
Meissner Manufacturing Division, Maguire Industries, Inc., Mt. Carmel, Ill.
Midwest Radio Corp., 909 Broadway, Cincinnati, Ohio
Minerva Corp. of America, 238 William St., New York, N. Y.
Noblitt Sparks Industries, Columbus, Indiana
Packard-Bell Co., 3443 Welshire Blvd., Los Angeles 5, Calif.
Philco Corporation, Tioga & C Streets, Philadelphia 34, Pa.
Philharmonic Radio Corporation, 528 East 72nd Street, New York 21, N. Y.
Precision Specialties, 210-26 N. Western Ave., Los Angeles, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Record-O-Vox, Inc., 721 N. Martel Avenue, Hollywood 46, Calif.
Remler Company, Ltd., 2101 Bryant Street, San Francisco 10, Calif.
Rex Products Co., 1313 W. Randolph St., Chicago 7, Ill.
Sentinel Radio Corp., 2020 Ridge Avenue, Evanston, Ill.
Sheridan Electro Corp., 2850 S. Michigan Ave., Chicago, Ill.
Signal Electronics, Inc., 114 East 16th St., New York 3, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Avenue, Chicago, Ill.
Sparks Withington Company, Jackson, Michigan
Stewart Warner Corporation, 1836 Diversey Parkway, Chicago, Ill.
Stromberg-Carlson Co., 100 Carlson Road, Rochester, N. Y.
Symphonic Radio & Electronic Corp., 292-98 Main St., Cambridge 42, Mass.
Tech-Master Prods. Co., 123 Prince St., New York, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Templetone Radio Mfg. Corp., Templetone Building, New London, Conn.
Trav-Ler Karenola, 571 W. Jackson Blvd., Chicago, Ill.
United States Television Mfg. Corp., 106 Seventh Avenue, New York, N. Y.
Viewtone Co., 203 East 18th St., New York, N. Y.
Vlectrical Engineering Co., 828 North Highland Avenue, Los Angeles 38, Calif.
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill.
Watterson Radio Mfg. Co., P O Box 54, Dallas, Texas
Wells Gardner & Co., 2701 North Kildare, Chicago 39, Ill.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.
Wilcox Gay Corp., Charlotte, Michigan
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

AM CONSOLES

Admiral Corporation, 3800 W. Cortland St., Chicago, Ill.
Andrea Radio Corp., 43-20 34th Street, Long Island City, N. Y.
Ansley Radio Corp., 21-10 49th Avenue, Long Island City, N. Y.
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Belmont Radio Corporation, 5921 West Dickens Avenue, Chicago 39, Ill.
Bendix Radio Corp., Baltimore 4, Md.
Colonial Radio Corp., 254 Rano St., Buffalo, N. Y.
Crosley Corporation, Cincinnati, Ohio
Delco Radio Division, General Motors Corporation, Kokomo, Indiana
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Echophone Radio, Division of Hallicrafters Co., 2611 S. Indiana Avenue, Chicago, Ill.
Eckstein Radio & Television Co., Inc., 914 LaSalle, Minneapolis, Minn.
Electrical Research & Mfg. Co., 3001 E. Pico Blvd., Los Angeles, Calif.
Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
Garod Radio Corp., 70 Washington St., Bklyn, N. Y.
General Electric Company, Bridgeport, Conn.
Hamilton Radio Corp., 510 Sixth Avenue, New York, N. Y.
Herbach & Rademan Co., 517 Ludlow St., Philadelphia 6, Pa.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles, Calif.
International Detrola Corp., 1501 Beard Ave., Detroit, Michigan
Kingston Products Corp., Kokomo, Indiana
Lear, Inc., Piqua, Ohio
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Majestic Radio & Television Corp., St. Charles, Ill.
Meck Industries, John, Liberty at Pennsylvania, Plymouth, Ind.
Megard Corporation, 1601 S. Burlington Avenue, Los Angeles 6, Calif.
Meissner Manufacturing Division, Maguire Industries, Inc., Mt. Carmel, Ill.
Midwest Radio Corp., 909 Broadway, Cincinnati, Ohio
Minerva Corp. of America, 238 William Street, New York, N. Y.
Noblitt Sparks Industries, Columbus, Indiana
Packard-Bell Co., 3443 Welshire Blvd., Los Angeles 5, Calif.
Philco Corporation, Tioga & C Streets, Philadelphia 34, Pa.
Philharmonic Radio Corporation, 528 East 72nd Street, New York 21, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.

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Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Regal Electronics Corp., 20 West 30th St., New York, N. Y.
Remler Company, Ltd., 2101 Bryant St., San Francisco 10, Calif.
Searle Aero Industries, Inc., Orange, Calif.
Sentinel Radio Corp., 2020 Ridge Ave., Evanston, Ill.
Signal Electronics, Inc., 114 East 16th St., New York 3, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Avenue, Chicago, Ill.
Sparks Withington Compny, Jackson, Michigan
Stewart Warner Corporation, 1836 Diversey Parkway, Chicago, Ill.
Stromberg-Carlson Co., 100 Carlson Road, Rochester, N. Y.
Symphonic Radio & Electronic Corp., 292-98 Main St., Cambridge 42, Mass.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Templetone Radio Mfg. Corp., Templetone Building, New London, Conn.
United States Television Mfg. Corp., 106 Seventh Avenue, New York, N. Y.
Viewtone Co., 203 East 18th St., New York, N. Y.
Vlectrical Engineering Co., 828 North Highland Avenue, Los Angeles 38, Calif.
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill.
Watterson Radio Mfg. Co., P O Box 54, Dallas, Texas
Wells Gardner & Co., 2701 North Kildare, Chicago 39, Ill.
Wilcox Gay Corporation, Charlotte, Michigan
Zenith Radio Corp., 6001 Dickens Avenue, Chicago, Ill.

AM PORTABLES

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Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Ansley Radio Corp., 21-10 49th Ave., Long Island City, N. Y.
Automatic Radio Mfg. Co., Inc., 122 Brookline Ave., Boston, Mass.
Belmont Radio Corporation, 5921 West Dickens Ave., Chicago 39, Ill.
Bendix Radio Corp., Baltimore 4, Md.
Colonial Radio Corp., 254 Rano St., Buffalo, N. Y.
Crosley Corporation, Cincinnati, Ohio
Delco Radio Division, General Motors Corporation, Kokomo, Indiana
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Echophone Radio, Div. of Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Eckstein Radio & Television Co. Inc., 914 La Salle, Minneapolis, Minn.
Electrical Research & Mfg. Co., 3001 E. Pico Blvd., Los Angeles, Calif.
Electromatic Mfg. Corp., 88 University Place, New York, N. Y.
Electronic Corp. of America, 45 West 18th St., New York, N. Y.
Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
Garod Radio Corp., 70 Washington St., Bklyn, N. Y.
General Electric Company, Bridgeport, Conn.
General Television & Radio Corp., 2701 North Lehmann Court, Chicago 14, Ill.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Hamilton Radio Corp., 510 Sixth Ave., New York, N. Y.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles, Calif.
Howard Radio Co., 1731 Belmont Ave., Chicago, Ill.
International Detrola Corp., 1501 Beard Ave., Detroit, Michigan
Keith Radio Products, 16th & K St., Bedford, Ind.
Kingston Products Corp., Kokomo, Indiana
Majestic Radio & Television Corp., St. Charles, Ill.
Meck Industries, John, Liberty at Pennsylvania, Plymouth, Ind.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Minerva Corp. of America, 238 William St., New York, N. Y.
Noblitt Sparks Industries, Columbus, Indiana
Packard-Bell Co., 3443 Welshire Blvd., Los Angeles 5, Calif.
Philco Corporation, Tioga & C Sts., Philadelphia 34, Pa.
Philharmonic Radio Corporation, 528 East 72nd St., New York 21, N. Y.
Pilot Radio Corp., 37-06 36th St., Long Island City, N. Y.
Radio Corp. of America, RCA Victor Division, Camden, N. J.
Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Remler Co., Ltd., 2101 Bryant St., San Francisco, Calif.
Rex Products Co., 1313 W. Randolph St., Chicago 7, Ill.
Searle Aero Industries, Inc., Orange, Calif.
Sentinel Radio Corp., 2020 Ridge Ave., Evanston, Ill.
Setchell Carlson, 2233 University Ave., St. Paul, Minn.
Sheridan Electro Corp., 2850 S. Michigan Ave., Chicago, Ill.
Signal Electronics, Inc., 114 East 16th St., New York 3, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago, Ill.
Sparks Withington Company, Jackson, Michigan
Stewart Warner Corporation, 1836 Diversey Parkway, Chicago, Ill.
Stromberg-Carlson Co., 100 Carlson Road, Rochester, N. Y.
Symphonic Radio & Electronic Corp., 292-98 Main St., Cambridge 42, Mass.
Tech-Master Prods. Co., 123 Prince St., New York, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Templetone Radio Mfg. Corp., Templetone Building, New London, Conn.
Trav-Ler Karenola, 571 W. Jackson Blvd., Chicago, Ill.
United States Television Mfg. Corp., 106 Seventh Avenue, New York, N. Y.
Viewtone Co., 203 East 18th St., New York, N. Y.
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill.
Whiting & Davis Company, Inc., 23 West Bacon St., Plainville, Mass.
Wells Gardner & Co., 2701 North Kildare, Chicago 39, Ill.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.
Wilcox Gay Corp., Charlotte, Michigan
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

AM TABLE MODELS

A R F Products Co., 7627 Lake St., River Forest, Ill.
Admiral Corporation, 3800 W. Cortland St., Chicago, Ill.
Air King Products Co. Inc., 1523-63rd St., Bklyn, N. Y.
Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Ansley Radio Corp., 21-10 49th Ave., Long Island City, N. Y.
Automatic Radio Mfg. Co. Inc., 122 Brookline Ave., Boston, Mass.
Belmont Radio Corporation, 5921 West Dickens Ave., Chicago 39, Ill.
Bendix Radio Corp., Baltimore 4, Md.
Colonial Radio Corp., 254 Rano St., Buffalo, N. Y.
The Crosley Corporation, Cincinnati 25, Ohio
Crystal Products Co., 1519 McGee Trafficway, Kansas City, Mo.
Delco Radio Division, General Motors Corporation, Kokomo, Indiana
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Echophone Radio, Division of Hallicrafters Co., 2611 S. Indiana Avenue, Chicago, Ill.
Eckstein Radio & Television Co. Inc., 914 LaSalle, Minneapolis, Minn.
Electrical Research & Mfg. Co., 3001 E. Pico Blvd., Los Angeles, Calif.
Electromatic Mfg. Corp., 88 University Place, New York, N. Y.
Electronic Corp. of America, 45 West 18th St., New York, N. Y.
Espey Mfg. Co. Inc., 33 West 46th St., New York, N. Y.
Fada Radio & Electric Co. Thomson Avenue, Long I... N. Y.
Farnsworth Television & R... 3700 Pontiac St., Fort W...
Galvin Mfg. Corp., 4545 Au... Chicago, Ill.
Garod Radio Corp., 70 Was... Brooklyn, N. Y.
General Electric Company, ... Conn.
General Television & Radio ... North Lehmann Court, ... Ill.
Gilfillan Bros. Inc., 1815 Ve... Los Angeles, Calif.
Hamilton Radio Corp., 510 S... New York, N. Y.
Hoffman Radio Corp., 3430 ... Los Angeles, Calif.
Howard Radio Co., 1731 Be... Chicago, Ill.
Industrial Tool & Die Works ... University Avenue, S. E., ... Minn.
International Detrola Corp., ... Ave., Detroit, Michigan
Keith Radio Products, 16th & ... ford, Ind.
Kingston Products Corp., Ko... ana
Lear, Inc., Piqua, Ohio
Majestic Radio & Television ... Charles, Ill.
Meck Industries, John, Liberty ... sylvania, Plymouth, Ind.
Medco Mfg. Co., 5 West 45... York, N. Y.
Megard Corporation, 1601 S. ... Avenue, Los Angeles 6, C...
Meissner Manufacturing Divisi... Industries, Inc., Mt. Carmel
Midwest Radio Corp., 909 Broa... cinnati, Ohio
Minerva Corp. of America, 23... St., New York, N. Y.
Noblitt Sparks Industries, Colu... diana
Packard-Bell Co., 3443 Welsh... Los Angeles 5, Calif.
Philco Corporation, Tioga & ... Philadelphia 34, Pa.
Philharmonic Radio Corporation, ... 72nd Street, New York 21, N...
Pilot Radio Corp., 37-06 36th ... Island City, N. Y.
Precision Specialties, 210-26 N... Ave., Los Angeles, Calif.
Radio Corp. of America, RCA ... vision, Camden, N. J.
Record-O-Vox, Inc., 721 N. Ma... Hollywood 46, Calif.
Regal Electronics Corp., 20 West ... New York, N. Y.
Remler Company, Ltd., 2101 ... Street, San Francisco 10, Cal...
Rex Products Co., 1313 W. Rand... Chicago 7, Ill.
Searle Aero Industries, Inc., Orang...
Sentinel Radio Corp., 2020 Ridge ... Evanston, Ill.
Setchell Carlson, 2233 Universi... St. Paul, Minn.
Sheridan Electro Corp., 2850 S. M... Ave., Chicago, Ill.
Signal Electronics, Inc., 114 East ... New York 3, N. Y.
Sonora Radio & Television Corp., ... Hoyne Avenue, Chicago, Ill.
Sparks Withington Company, ... Michigan
Stewart Warner Corporation, 1836 ... sey Parkway, Chicago, Ill.
Stromberg-Carlson Co., 100 Carlso... Rochester, N. Y.
Symphonic Radio & Electronic Corp., ... 98 Main St., Cambridge 42, Mass.
Tech-Master Prods. Co., 123 Prince ... New York, N. Y.
Telicon Corp., 851 Madison Ave., ... York, N. Y.
Templetone Radio Mfg. Corp., Temple... Building, New London, Conn.
Trav-Ler Karenola, 571 W. Jackson ... Chicago, Ill.
United States Television Mfg. Corp., ... Seventh Avenue, New York, N. Y.
Viewtone Co., 203 East 18th St., ... York, N. Y.
Vlectrical Engineering Co., 828 N... Highland Avenue, Los Angeles ... Calif.
Warwick Mfg. Corp., 4640 W. Harr... St., Chicago, Ill.
Watterson Radio Mfg. Co., P O Box ... Dallas, Texas
Wells Gardner & Co., 2701 North Kil... Chicago 39, Ill.

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Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.
Whiting & Davis Company, Inc., 23 West Bacon Street, Plainville, Mass.
Wilcox Gay Corp., Charlotte, Michigan
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

AM VEST POCKETS

Automatic Radio Mfg. Co. Inc., 122 Brookline Ave., Boston, Mass.
Bendix Radio Corp., Baltimore 4, Md.
Colonial Radio Corp., 254 Rano St., Buffalo, N. Y.
Delco Radio Division, General Motors Corporation, Kokomo, Indiana
Electronic Corp. of America, 45 West 18th St., New York, N. Y.
Fada Radio & Electric Co., Inc., 30-20 Thomson Avenue, Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
International Detrola Corp., 1501 Beard Avenue, Detroit, Mich.
Keith Radio Products, 16th & K St., Bedford, Ind.
Meck Industries, John, Liberty at Pennsylvania, Plymouth, Ind.
Noblitt Sparks Industries, Columbus, Indiana
Philco Corporation, Tioga & C Streets, Philadelphia 34, Pa.
Philharmonic Radio Corporation, 528 East 72nd Street, New York 21, N. Y.
Sentinel Radio Corp., 2020 Ridge Avenue, Evanston, Ill.
Sheridan Electro Corp., 2850 S. Michigan Ave., Chicago, Ill.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Templetone Radio Mfg. Corp., Templetone Building, New London, Conn.
Wells Gardner & Co., 2701 North Kildare, Chicago 39, Ill.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

Receivers, Home—AM-FM

AM-FM COMBINATIONS

Admiral Corporation, 3800 W. Cortland St., Chicago, Ill.
Air-King Products Co. Inc., 1523-63rd St., Brooklyn, N. Y.
Ansley Radio Corp., 21-10 49th Ave., Long Island City, N. Y.
Belmont Radio Corporation, 5921 West Dickens Avenue, Chicago 39, Ill.
Bendix Radio Corp., Baltimore 4, Md.
Colonial Radio Corp., 254 Rano Street, Buffalo, N. Y.
The Crosley Corporation, Cincinnati 25, Ohio
Delco Radio Division, General Motors Corporation, Kokomo, Indiana
Echophone Radio, Division of Hallicrafters Co., 2611 S. Indiana Avenue, Chicago, Ill.
Electrical Research & Mfg. Co., 3001 E. Pico Blvd., Los Angeles, Calif.
Electronic Corp. of America, 45 West 18th Street, New York, N. Y.
Espey Mfg. Co. Inc., 33 West 46th St., New York, N. Y.
Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
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Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
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Magnavox Company, Fort Wayne, Indiana.
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Meck Industries, Plymouth, Ind.
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Remler Co. Ltd., 2101 Bryant St., San Francisco, Calif.
Scott Radio Labs. Inc., 4541 Ravenswood Avenue, Chicago, Ill.
Sentinel Radio Corp., 2020 Ridge Avenue, Evanston, Ill.
Sheridan Electro Corp., 2850 S. Michigan Ave., Chicago, Ill.
Signal Electronics, Inc., 114 East 16th St., New York 3, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Avenue, Chicago, Ill.
Sparks Withington Co., Jackson, Michigan
Stewart Warner Corporation, 1836 Diversey Parkway, Chicago, Ill.
Stromberg-Carlson Co., Rochester, N. Y.
Tech-Master Prods. Co., 12 Prince St., New York, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Templetone Radio Mfg. Corp., Templetone Building, New London, Conn.
Viewtone Co., 203 East 18th St., New York, N. Y.
Vlectrical Engineering Co., 828 North Highland Avenue, Los Angeles 38, Calif.
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill.
Wells Gardner & Co., 2701 North Kildare, Chicago 39, Ill.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.
Wilcox Gay Corporation, Charlotte, Mich.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

AM-FM CONSOLES

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Belmont Radio Corporation, 5921 West Dickens Avenue, Chicago 39, Ill.
Bendix Radio Corp., Baltimore 4, Md.
Colonial Radio Corp., 254 Rano St., Buffalo, N. Y.
Crosley Corporation, Cincinnati 25, Ohio
Delco Radio Division, General Motors Corporation, Kokomo, Indiana
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Fada Radio & Electric Co. Inc., 30-20 Thomas Ave., Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
Garod Radio Corp., 70 Washington St., Bklyn, N. Y.
General Electric Co., Bridgeport, Conn.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Hamilton Radio Corp., 510 Sixth Ave., New York, N. Y.
Herbach & Rademan, 517 Ludlow St., Philadelphia 6, Pa.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles, Calif.
Howard Radio Co., 1731 Belmont Ave., Chicago Ill.
International Detrola Corp., 1501 Beard Ave., Detroit, Mich.
Kingston Radio Products Corp., Kokomo, Indiana
Lear, Inc., Piqua, Ohio
Magnavox Company, 2131 Bueter Road, Fort Wayne, Indiana
Majestic Radio & Television Corp., St. Charles, Illinois
Meck Industries, John, Liberty at Pennsylvania, Plymouth, Ind.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Megard Corporation, 1601 S. Burlington Ave., Los Angeles 6, Calif.
Meissner Manufacturing Division, Maguire Industries, Inc., Mt. Carmel, Ill.
Midwest Radio Corp., 909 Broadway, Cincinnati, Ohio
Minerva Corp. of America, 238 William St., New York, N. Y.
Noblitt Sparks Industries, Columbus, Ind.
Packard-Bell Co., 3443 Welshire Blvd., Los Angeles 5, Calif.
Philco Corporation, Tioga & C Sts., Philadelphia 34, Pa.
Philharmonic Radio Corporation, 528 East 72nd St., New York 21, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Remler Co. Ltd., 2101 Bryant St., San Francisco, Calif.
Scott Radio Labs. Inc., 4541 Ravenswood Ave., Chicago, Ill.
Sentinel Radio Corp., 2020 Ridge Ave. Evanston, Ill.
Sheridan Electro Corp., 2850 S. Michigan Ave., Chicago, Ill.
Signal Electronics, Inc., 114 East 16th St., New York 3, N. Y.
Sonora Radio & Television Corp., 325 N Hoyne Ave., Chicago, Ill.
Stewart Warner Corporation, 1836 Diversey Parkway, Chicago, Ill.
Stromberg-Carlson Co., 100 Carlson Road Rochester, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Templetone Radio Mfg. Corp., Templetone Building, New London, Conn.
United States Television Mfg. Corp., 106 Seventh Avenue, New York, N. Y.
Viewtone Co., 203 East 18th St., New York, N. Y.
Vlectrical Engineering Co., 828 North Highland Ave., Los Angeles 38, Calif
Wells Gardner & Co., 2701 North Kildare, Chicago 39, Ill.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.
Wilcox Gay Corporation, Charlotte, Michigan
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

AM-FM PORTABLES

Admiral Corporation, 3800 W. Cortland St., Chicago, Ill.
Echophone Radio Division of Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Electrical Research & Mfg. Co., 3001 E Pico Blvd., Los Angeles, Calif.
Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Hallicrafters Co., 2611 Indiana Ave., Chicago 16, Ill.
Hoffman Radio Corp., 3430 S. Hill St. Los Angeles, Calif.
Keith Radio Products, 16th & K Sts., Bedford, Ind.
Minerva Corp. of America, 238 William St., New York, N. Y.
Packard-Bell Co., 3443 Welshire Blvd., Los Angeles 5, Calif.
Philco Corporation, Tioga & C Sts., Philadelphia 34, Pa.
Philharmonic Radio Corporation, 528 East 72nd St., New York 21, N. Y.
Ray Energy and Television Corp. of America, 521 Fifth Ave., New York N. Y.
Sentinel Radio Corp., 2020 Ridge Ave. Evanston, Ill.
Signal Electronics, Inc., 114 East 16th St. New York 3, N. Y.
Sonora Radio & Television Corp., 325 N Hoyne Ave., Chicago, Ill.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Vlectrical Engineering Co., 828 North Highland Ave., Los Angeles 38, Calif
Zenith Radio Corp., 6001 Dickens Ave. Chicago, Ill.

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AM-FM TABLE MODELS

A R F Products Co., 7627 W. Lake St., River Forest, Ill.
Admiral Corporation, 3800 W. Cortland St., Chicago, Ill.
Air-King Products Co. Inc., 1523-63rd St., Bklyn, N. Y.
Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Belmont Radio Corporation, 5921 West Dickens Avenue, Chicago 39, Ill.
Bendix Radio Corp., Baltimore 4, Md.
Colonial Radio Corp., 254 Rano St., Buffalo, N. Y.
Crosley Corporation, Cincinnati 25, Ohio
Delco Radio Division, General Motors Corporation, Kokomo, Indiana
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Echophone Radio Division of Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Electrical Research & Mfg. Co., 3001 E. Pico Blvd., Los Angeles, Calif.
Electronic Corp. of America, 45 West 18th Street, New York, N. Y.
Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
Garod Radio Corp., 70 Washington St., Bklyn, N. Y.
General Electric Co., Bridgeport, Conn.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Hamilton Radio Corp., 510 Sixth Ave., New York, N. Y.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles, Calif.
Howard Radio Co., 1731 Belmont Ave., Chicago, Ill.
Industrial Tool & Die Works, Inc., 2824 University Ave., S. E., Minneapolis, Minn.
International Detrola Corp., 1501 Beard Ave., Detroit, Mich.
Keith Radio Products, 16th & K St., Bedford, Ind.
Kingston Radio Products Corp., Kokomo, Indiana
Majestic Radio & Television Corp., St. Charles, Illinois
Meck Industries, John, Liberty at Pennsylvania, Plymouth, Ind.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Megard Corporation, 1601 S. Burlington Ave., Los Angeles 6, Calif.
Midwest Radio Corp., 909 Broadway, Cincinnati, Ohio
Minerva Corp. of America, 238 William St., New York, N. Y.
Noblitt Sparks Industries, Columbus, Indiana
Packard-Bell Co., 3443 Welshire Blvd., Los Angeles 5, Calif.
Philco Corporation, Tioga & C Sts., Philadelphia 34, Pa.
Philharmonic Radio Corporation, 528 East 72nd St., New York 21, N. Y.
Pilot Radio Corp., 37-06 36th St., Long Island City, N. Y.
Precision Specialties, 210-26 N. Western Ave., Los Angeles, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Ray Energy and Television Corp. of America, 521 Fifth Avenue, New York, N. Y.
Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Remler Co. Ltd., 2101 Bryant St., San Francisco, Calif.
Searle Aero Industries, Inc., Orange, Calif.
Sentinel Radio Corp., 2020 Ridge Ave., Evanston, Ill.
Sheridan Electro Corp., 2850 S. Michigan Ave., Chicago, Ill.
Signal Electronics, Inc., 114 East 16th St., New York 3, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago, Ill.
Sparks Withington Co., Jackson, Michigan
Stewart Warner Corporation, 1836 Diversey Parkway, Chicago, Ill.
Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
Tech-Master Prods. Co., 123 Prince St., New York, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Templetone Radio Mfg. Corp., Templetone Building, New London, Conn.
Trav-Ler Karenola, 571 W. Jackson Blvd., Chicago, Ill.
Viewtone Co., 203 East 18th St., New York, N. Y.
Vlectrical Engineering Co., 828 North Highland Ave., Los Angeles 38, Calif.
Warwick Mfg. Corp., 4640 W. Harrison St., Chicago, Ill.
Wells Gardner & Co., 2701 North Kildare, Chicago 39, Ill.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

Receivers, Home—FM

FM COMBINATIONS

Belmont Radio Corporation, 5921 West Dickens Ave., Chicago 39, Ill.
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Megard Corp., 1601 S. Burlington Ave., Los Angeles 6, Calif.
Ray Energy and Television Corp. of America, 521 Fifth Ave., New York, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.

FM CONSOLES

Belmont Radio Corporation, 5921 West Dickens Ave., Chicago 39, Ill.
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Megard Corporation, 1601 S. Burlington Ave., Los Angeles 6, Calif.
Telicon Corp., 851 Madison Ave., New York, N. Y.

FM PORTABLES

Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Ray Energy and Television Corp. of America, 521 Fifth Avenue, New York, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Trav-Ler Karenola, 571 W. Jackson Blvd., Chicago, Ill.

FM TABLE MODELS

Belmont Radio Corporation, 5921 West Dickens Ave., Chicago 39, Ill.
Colonial Radio Corp., 254 Rano St., Buffalo 7, N. Y.
DeWald Radio Mfg. Corp., 440 Lafayette St., New York, N. Y.
Fada Radio & Electric Co. Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Gilfillan Bros. Inc., 1815 Venice Blvd., Los Angeles, Calif.
Industrial Tool & Die Works, Inc., 2824 University Ave., S. E., Minneapolis, Minn.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Megard Corporation, 1601 S. Burlington Ave., Los Angeles 6, Calif.
Meissner Manufacturing Division, Maguire Industries, Inc., Mt. Carmel, Ill.
Ray Energy and Television Corp. of America, 521 Fifth Ave., New York, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago, Ill.
Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.
Trav-Ler Karenola, 571 W. Jackson Blvd., Chicago, Ill.

FM VEST POCKETS

Fada Radio & Electric Co. Inc., 30-20 Thomson Avenue, Long Island City, N. Y.
Ray Energy and Television Corp. of America, 521 Fifth Ave., New York, N. Y.
Telicon Corp., 851 Madison Ave., New York, N. Y.

Receivers

RADIO, AIRCRAFT

Bendix Radio Corp., Baltimore 4, Md.
Collins Radio Co., Cedar Rapids, Iowa
Colonial Radio Corp., 254 Rano St., Buffalo 7, N. Y.
Gates Radio & Supply Co., Quincy, Ill.
General Electric Co., Bridgeport, Conn.
Gilfillan Bros., Inc., 1815 Venice Blvd., Los Angeles, Calif.
Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Herbach & Rademan Co., 517 Ludlow St., Philadelphia 6, Pa.
Lear, Inc., Piqua, Ohio
Midwest Radio Corp., 909 Broadway, Cincinnati, Ohio
Radio Receptor Co., Inc., 251 West 19th St., New York, N. Y.
Raytheon Mfg. Co., 60 East 42nd St., New York 17, N. Y.
Searle Aero Industries, Inc., Orange, Calif.

PANORAMIC RECEIVERS

Hallicrafters Co., 2611 Indiana Avenue, Chicago 16, Ill.
Panoramic Radio Corporation, 242 West 55th St., New York 19, N. Y.

RADIO COMPASS RECEIVERS

Air Communications, Inc., 2233 Grand Ave., Kansas City 8, Mo.
Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kansas
Airplane & Marine Instruments, Inc., Clearfield, Pa.
Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Ansley Radio Corp., 21-10 49th Ave., Long Island City, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bassett, Inc., Rex, 500 S. E. Second St., Ft. Lauderdale, Fla.
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago 39, Ill.
Bendix Radio Div., Bendix Aviation Corp., Baltimore 4, Md.
Collins Radio Co., 855-35th St. N. E., Cedar Rapids, Iowa
Communications Co., Inc., 300 Greco Ave., Coral Gables 34, Fla.
Communications Equipment Corp., 134 West Colorado St., Pasadena 1, Calif.
Crosley Corp., 1329 Arlington St., Cincinnati 3, Ohio
Fairchild Camera & Instrument Corp., 475 Tenth Ave., New York 18, N. Y.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Finch Telecommunications, Inc., Passaic, N. J.
Fisher Research Laboratory, 1961 University Ave., Palo Alto, Cal.
Garod Radio Corp., 70 Washington St., Brooklyn, N. Y.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
Giannini & Co., Inc., G. M., 161 E. California St., Pasadena, Calif.
Grady Instrument Co., 11 Bailey Ave., Watertown 72, Mass.
Gray Radio Co., 730 Okeeshobee Rd., West Palm Beach, Fla.
Hallicrafters Co., 2611 Indiana Ave., Chicago 16, Ill.
Harvey Radio Laboratories, Inc., 447 Concord Ave., Cambridge, Mass.
Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Heath Co., Benton Harbor, Mich.
Hudson American Corp., 25 W. 43rd St., New York, N. Y.
Islip Radio Manufacturing Corp., Foot of Beech St., Islip, New York
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, L. I., N. Y.
Jefferson-Travis Radio Mfg. Corp., 345 East 23rd St., New York 10, N. Y.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lear, Inc., Piqua, Ohio
Magnavox Co., The, 2131 Bueter Rd., Fort Wayne 4, Ind.
McGrade Mfg. Co., E. W., 406 West 34th St., Kansas City, Mo.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
National Co., 61 Sherman St., Malden 48, Mass.

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ELECTRONIC and ALLIED PRODUCTS

Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Panoramic Radio Corp., 242 W. 55th St., New York 19, N. Y.
Philharmonic Radio Corp., 528 E. 72nd St., New York 21, N. Y.
Press Wireless, Inc., 1475 Broadway, New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Laboratories, Inc., 2701 California Ave., Seattle 6, Washington
Radio Mfg. Engineers, Inc., 304 First Ave., Peoria, Ill.
Radio Navigational Instrument Corp., 500 Fifth Ave., New York, N. Y.
Radiomarine Corp. of America, 75 Varick St., New York, N. Y.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Sargent Co., E. M., 212 Ninth St., Oakland, Calif.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago 12, Ill.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Sperry Gyroscope Co., Inc., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Technical Radio Co., 275 Ninth St., San Francisco, Calif.
U. S. Television Manufacturing Corp., 106 Seventh Ave., New York 11, N. Y.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Wilcox Electric Co., 1400 Chestnut St., Kansas City, Mo.

RAILROAD RECEIVERS

Aireon Mfg. Corp., Kansas City, Kans.
Bendix Radio Corp., Baltimore 4, Md.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
General Electric Co., Bridgeport, Conn.
Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Herbach & Rademan Co., 517 Ludlow St., Philadelphia 6, Pa.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., 60 East 42nd St., New York 17, N. Y.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.

TELEVISION RECEIVERS

Andrea Radio Corp., 43-20 34th St., Long Island City, N. Y.
Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J.
Echophone Radio Div. of Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
General Electric Co., Bridgeport, Conn.
Hallicrafters Co., 2611 Indiana Ave., Chicago 16, Ill.
Philco Corporation, Tioga & C Sts., Philadelphia 34, Pa.
Pilot Radio Corp., 37-06 36th St., Long Island City, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago, Ill.
Telicon Corporation, 851 Madison Ave., New York, N. Y.
United States Television Mfg. Corp., 106 Seventh Avenue, New York, New York
Viewtone Co., 203 East 18th St., New York, N. Y.

RECEIVERS, OTHER

Abbott Instrument, Inc., 8 West 18th St., New York, N. Y.
Aero Communications, Inc., 231 Main St., Hempstead, Long Island, N. Y.
Air Associates, Inc., 5827 W. Century Blvd., Los Angeles 45, Calif.
Air Communications, Inc., 2233 Grand Ave., Kansas City, Mo.
Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kans.
Aircraft Radio Corp., Boonton, N. J.
Airplane & Marine Instruments, Inc., Clearfield, Pa.
American Communications Corp., 306 Broadway, New York, N. Y.
American Radio Co., 611 E. Garfield Ave., Glendale, Calif.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Autocrat Radio Co., 3855 N. Hamilton Ave., Chicago, Ill.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bassett, Inc., Rex, 500 S. E. Second St., Ft. Lauderdale, Fla.
Collins Radio Co., 855 35th St., N. E., Cedar Rapids, Iowa
Communications Co., 300 Greco Ave., Coral Gables 34, Fla.
Communications Equipment Corp., 134 W. Colorado St., Pasadena 1, Calif.
Doolittle Radio, Inc., 7421 S. Loomis Blvd., Chicago, Ill.
Electrical Engineering Co., Los Angeles, Calif.
Electronic Specialty Co., 3456 Glendale Blvd., Los Angeles, Calif.
Electronic Measurements Co., Red Bank, N. J.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Fisher Research Laboratory, 1961 University Ave., Palo Alto, Calif.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
Harvey Machine Co., 6200 Avalon Blvd., Los Angeles, Calif.
Harvey Radio Laboratories, Inc., 447 Concord Ave., Cambridge, Mass.
Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Hatcher & Fisk, 125 Kansas Ave., Topeka, Kans.
Hazeltine Electronics Corp., 1775 Broadway, New York, N. Y.
Heath Co., Benton Harbor, Mich.
Higgins Industries, 2221 Warwick Ave., Santa Monica, Calif.
Hudson American Corp., 25 West 43rd St., New York, N. Y.
Islip Radio Mfg. Corp., foot of Beech St., Islip, N. Y.
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, Long Island, N. Y.
Jefferson-Travis Radio Mfg. Corp., 245 East 23rd St., New York 10, N. Y.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Link, Fred M., 125 West 17th St., New York, N. Y.
Maritime Radio Corp., 24 Whitehall St., New York, N. Y.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., 61 Sherman St., Malden 48, Mass.
Oregon Electric Mfg. Co., 206 S. W. Washington St., Portland, Ore.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Press Wireless Inc., 1475 Broadway, New York, N. Y.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Radio Craftsmen, 1341 S. Michigan Ave., Chicago 5, Ill.
Radio Engineering Laboratories, Inc., 35-54 36th St., Long Island City, N. Y.
Radio Laboratories Inc., 2701 California Ave., Seattle 6, Wash.
Radio Mfg. Engineers, Inc., 304 First Ave., Peoria, Ill.
Radio Navigational Instrument Corp., 500 Fifth Ave., New York, N. Y.
Radiomarine Corp. of America, 75 Varick St., New York, N. Y.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Sargent Co., E. M., 212 Ninth St., Oakland, Calif.
Schuttig & Co., 9th & Kearney Sts., N. E., Washington 17, D. C.
Sherron Electronics, 1201 Flushing Ave., Brooklyn 6, N. Y.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Taybern Equipment Co., 120 Greenwich St., New York 6, N. Y.
Technical Devices Corp., Beaufort & Eagle Rock Ave., Roseland, N. J.
Technical Radio Co., 275 Ninth St., San Francisco, Calif.
Telex Products Co., Telex Park, Minneapolis, Minn.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York, N. Y.
Trebor Radio Co., Pasadena, Calif.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Walsh Engineering Co., 34 De Hart Place, Elizabeth, N. J.
Western Electric Co., Inc., 120 Broadway, New York, N. Y.
Wilcox Electric Co., 1400 Chestnut St., Kansas City, Mo.

Record Changers

see Changers, Record

Record Players

see Phonographs

Recorders

see Indicators

FREQUENCY RECORDERS

Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Conn Ltd., C. G., Elkhart, Ind.
General Electric Co., Schenectady 5, N. Y.
Hathaway Instrument Co., 1315 S. Clarkson St., Denver 10, Colo.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Sound Apparatus Co., 233 Broadway, New York 7, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
White Research, 899 Boylston St., Boston, Mass.

NOISE RECORDERS

Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Electronic Supply Co., 207 Main St., Worcester, Mass.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Massa Laboratories, Inc., 3868 Carnegie Ave., Cleveland, Ohio
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Presto Recording Corp., 242 West 55th St., New York, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.

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see pH Meters

SOUND RECORDERS and CUTTING HEADS

Allied Recording Products Co., 21-09 43rd Ave., Long Island City 1, N. Y.
Andrea Radio Corp., 43-20 24th St., Long Island City 1, N. Y.
Annis Co., R. B., 1101 N. Delaware St., Indianapolis 2, Ind.
Astatic Corp., Conneaut, Ohio
Audak Co., 500 Fifth Ave., New York, N. Y.
Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Autocrat Radio Co., 3855 N. Hamilton Ave., Chicago, Ill.
Bell Sound Systems, Inc., 1183 Essex Ave., Columbus, Ohio
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago, Ill.
Boetsch Brothers, 221 E. 144th St., New York 51, N. Y.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Carrilitone Mfg. Corp., 30 N. Penn St., York, Pa.
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Dictaphone Corp., 420 Lexington Ave., New York, N. Y.
Duotone Co., 799 Broadway, New York, N. Y.
Electronic Sound Engineering Co., 109 N. Dearborn St., Chicago 2, Ill.

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Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Fairchild Camera & Instrument Corp., 475 Tenth Ave., New York, N. Y.
Federal Instrument Co., 3931-47th Ave., Long Island City 4, N. Y.
Federal Recorder Co., Elkhart, Ind.
Galvin Mfg. Corp., 4545 W. Augusta Blvd., Chicago 51, Ill.
Garod Radio Corp., 70 Washington St., Brooklyn, N. Y.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
General Industries Co., Taylor & Olive Sts., Elyria, Ohio
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Gray Mfg. Co., 16-30 Arbor St., Hartford, Conn.
Hart & Co., Inc., Frederick, Recordgraph Div., 350 Madison Ave., New York 17, N. Y.
Howard Radio Co., 1735 Belmont Ave., Chicago 13, Ill.
Jefferson-Travis Radio Mfg. Corp., 245 East 23rd St., New York 10, N. Y.
Lear, Inc., Piqua, Ohio
Lewyt Corp., 60 Broadway, Bklyn, N. Y.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meissner Mfg. Div. Maguire Industries, Inc., Mt. Carmel, Ill.
Memovox Incorporated, 9242 Beverly Blvd., Beverly Hills, Calif.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Mirror Record Corp., 58 West 25th St., New York, N. Y.
Montgomery Bros., 61 Fremont St., San Francisco 5, Calif.
Music Master Mfg. Co., 542 S. Dearborn St., Chicago 5, Ill.
Pacific Sound Equipment Co., 1534 Cahuenga Blvd., Hollywood, Calif.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Proctor Co., Inc., B. A., 2 W. 45th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radiotechnic Laboratory, 1328 Sherman Ave., Evanston, Ill.
Radiotone Div., Robinson Houchin Optical Co., Columbus, Ohio
Record-O-Vox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Rek-O-Kut Co., 173 Lafayette St., New York 13, N. Y.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Robinson Recording Laboratories, 35 S. Ninth St., Philadelphia, Pa.
Scully Machine Co., 62 Walter St., Bridgeport, Conn.
Seeburg Corp., J. P., 1510 N. Dayton St., Chicago, Ill.
Shure Brothers, 225 W. Huron St., Chicago, Ill.
Simpson Mfg. Co., Inc., Mark, 188 West Fourth St., New York, N. Y.
SOS Cinema Supply Co., 449 West 42nd St., New York 18, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago 12, Ill.
Sound Apparatus Co., 233 Broadway, New York 7, N. Y.
SoundScriber Corp., 82 Audubon St., New Haven 11, Conn.
Speak-O-Phone Recording & Equipment Co., 23 W. 60th St., New York, N. Y.
Talk-A-Phone Mfg. Co., 1512 S. Pulaski Road, Chicago 23, Ill.
Talking Devices Co., 4447 W. Irving Park Rd., Chicago, Ill.
Universal Microphone Co., 424 Warren Lane, Inglewood, Calif.
Webster Electric Co., 1900 Clark St., Racine, Wisc.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago 47, Ill.
Western Sound & Electric Laboratories, 3512 W. St. Paul Ave., Milwaukee, Wisc.
Wilcox Gay Corp., Charlotte, Mich.

STEEL TAPE AND WIRE RECORDERS

Ansley Radio Corp., 21-10 49th Ave., Long Island City, N. Y.
Automatic Electric Co., 1033 W. Van Buren St., Chicago, Ill.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
California Telephone & Electric Co., 6075 W. Pico Blvd., Los Angeles, Calif.
Colonial Radio Corp., 254 Rano St., Buffalo, N. Y.
Conn, Ltd., C. G., Elkhart, Ind.
Echophone Radio, Div. of Hallicrafters Co., 2611 S. Indiana Ave., Chicago 16, Ill.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Ft. Wayne, Ind.
General Electric Co., Schenectady 5, N. Y.
Hallicrafters Co., 2611 Indiana Ave., Chicago 16, Ill.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles, Calif.
International Detrola Corp., Beard at Chatfield, Detroit, Mich.
Lear, Inc., Piqua, Ohio
Lewyt Corp., 60 Broadway, Brooklyn 11, N. Y.
Magnograph Corp., 5800 W. Third St., Los Angeles, Calif.
Magnavox Co., 2131 Bueter Rd., Ft. Wayne, Ind.
Mechanitron Corp., 711 Boylston St., Boston 16, Mass.
Meck Industries, John, Liberty at Pennsylvania, Plymouth, Ind.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Packard-Bell Co., 3443 Welshire Blvd., Los Angeles 5, Calif.
Precision Specialties, 210-26 North Western Ave., Los Angeles, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radiotechnic Laboratory, 1328 Sherman Ave., Evanston, Ill.
Raytheon Mfg. Co., Newton, Mass.
Scott Radio Laboratories, Inc., E. H., 4450 N. Ravenswood Ave., Chicago 40, Ill.
Seeburg Corp., J. P., 1500 N. Dayton Ave., Chicago 22, Ill.
Signal Electronics, Inc., 114 East 16th St., New York 3, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago 12, Ill.
Sparks Withington Co., Jackson, Mich.
Stromberg-Carlson Co., Rochester, N. Y.
Utah Radio Products Corp., 820 Orleans St., Chicago, Ill.
Vlectrical Engineering Co., 828 N. Highland Ave., Los Angeles 38, Calif.
Western Electric Co., 195 Broadway, New York, N. Y.
WIRecorder Corp., Detroit, Mich.
Wire Recorder Development Corp. (Armour Research Foundation), 8 S. Michigan Ave., Chicago 3, Ill.

TIME AND MOTION RECORDERS

Gorrell & Gorrell, 40 Littlefield Road, Newton Center, Mass.
Marsto Instrument Co., 1637A Beacon St., Waban, Mass.

Recording Blanks

see Discs

Records

PHONOGRAPH RECORDS

Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Carillitone Corp., 30 N. Penn St., York, Pa.
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Columbia Recording Corp., 1473 Barnum Ave., Bridgeport, Conn.
Decca Records, Inc., 50 West 57th St., New York 19, N. Y.
Majestic Records, Inc., St. Charles, Ill.
Poinsetta, Inc., 95 Cedar Ave., Pitman, N. J.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Riggs & Jeffreys, Inc., 73 Winthrop St., Newark 4, N. J.
Robinson Recording Laboratories, 35 S. Ninth St., Philadelphia, Pa.
Sonart Record Corp., 251 West 42nd St., New York 18, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago 12, Ill.
Stark Sound Engrg. Corp., P. O. 493, Fort Wayne 1, Ind.
Talking Devices Co., 4447 W. Irving Park Rd., Chicago, Ill.
WOR Feature Records, 1440 Broadway, New York, N. Y.
World Broadcasting System, 711 Fifth Ave., New York 22, N. Y.

Rectifiers

see also Tubes

DRY DISC RECTIFIERS

American Battery Co., 17 S. Jefferson St., Chicago, Ill.
American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
American Transformer Co., 178 Emmet St., Newark, N. J.
Benwood Linze Co., 1815 Locust St., St. Louis 3, Mo.
Bradley Labs., Inc., 82 Meadow St., New Haven 10, Conn.
Conant Electrical Labs, 6500 O Street, Lincoln, Nebr.
DeJur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Electrical Facilities, Inc., 4224 Holden St., Oakland 8, Calif.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electro Engineering & Mfg. Co., 627 W. Alexandrine Ave., Detroit 1, Mich.
Electro Products Laboratories, 549 W. Randolph St., Chicago, Ill.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Fansteel Metallurgical Corp., 2200 Sheridan Rd., North Chicago, Ill.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
General Electric Co., Bridgeport, Conn.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Green Electric Co., Inc., W., 130 Cedar St., New York 6, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
McColpin-Christie Corp., Ltd., 4922 S. Figueroa St., Los Angeles 37, Calif.
McInerney Plastics Co., 655 Godfrey Ave. S. W., Grand Rapids, Mich.
Radio Receptor Co., Inc., 251 West 19th St., New York, N. Y.
Schauer Machine Co., 2060 Reading Rd., Cincinnati 2, Ohio
Selenium Corp. of America, 1719 W. Pico Blvd., Los Angeles 15, Calif.
Union Switch & Signal Co., Swissvale, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Freylinghuysen Ave., Newark 5, N. J.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

TUBE RECTIFIERS

Allis Chalmers Mfg. Co., Milwaukee 1, Wisc.
American Battery Co., 17 S. Jefferson St., Chicago, Ill.
American Transformer Co., 178 Emmet St., Newark, N. J.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Baldor Electric Co., 4353 Duncan Ave., St. Louis, Mo.
Bunnell & Co., J. H., 215 Fulton St., New York, N. Y.
Communications Co., Inc., 300 Greco Ave., Coral Gables 34, Fla.
Continental Electric Co., 903 Merchandise Mart, Chicago 54, Ill.
Eitel-McCullough, Inc., San Bruno, Calif.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electro Products Laboratories, 549 W. Randolph St., Chicago, Ill.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Products Co., 111 E. Third St., Mt. Vernon, N. Y.
Electrons, Inc., 127 Sussex Ave., Newark, N. J.
Eureka X-Ray Tube Corp., 3250 N. Kilpatrick Ave., Chicago, Ill.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
France Mfg. Co., 10325 Berea Rd., Cleveland, Ohio
General Electric Co., Bridgeport, Conn.
General Electronics, Inc., 101 Hazel St., Paterson, N. J.
Green Electric Co., Inc., W., 130 Cedar St., New York 6, N. Y.

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ELECTRONIC and ALLIED PRODUCTS

Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass.
Kalb Electric Co., 2711 Big Bend Blvd., St. Louis, Mo.
Lewis Electronics, Inc., Los Gatos, Calif.
Litton Engineering Labs., P. O. Box 749, Redwood City, Calif.
McColpin-Christie Corp., Ltd., 4922 S. Figueroa St., Los Angeles 37, Calif.
Master Electric Co., 126 Davis Ave., Dayton, Ohio
Mellaphone Corp., Rochester 2, N. Y.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Pier Equipment Mfg. Co., Benton Harbor, Mich.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Selenium Corp. of America, 1800 West Pico Blvd., Los Angeles 15, Calif.
SOS Cinema Supply Co., 449 West 42nd St., New York 18, N. Y.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago 47, Ill.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York 14, N. Y.
Universal X-Ray Products, Inc., 1800 North Francisco Ave., Chicago 47, Ill.
Weltronic Co., 3080 E. Outer Drive, Detroit 17, Mich.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

Regulators

see also Transformers
also Tubes

VOLTAGE REGULATORS and STABILIZERS

Acme Electric & Mfg. Co., 31 Water St., Cuba, N. Y.
Allis Chalmers Mfg. Co., Milwaukee 1, Wisc.
American Transformer Co., 178 Emmet St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Avia Products Co., 7266 Beverly Blvd., Los Angeles 36, Cal. (Bases)
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bogue Electric Co., Paterson, N. J.
Burlington Instrument Corp., 214 North 4th St., Burlington, Iowa
Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn 1, N. Y.
Commercial Research Labs. Inc., 20 Bartlett Ave., Detroit 3, Mich.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, New Jersey
Electric Auto-Lite Co., Toledo, Ohio
Electric Sorting Machine Co., 410 Dennis Road, S.W., Grand Rapids, Mich.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Engineering Co., 3223 West Armitage Ave., Chicago, Ill.
Electronic Measurements Co., Red Bank, N. J.
Electronic Products Co., 19 North First St., Geneva, Ill.
Ferranti Electric, 30 Rockefeller Plaza, New York 20, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Electronics, Inc., 101 Hazel St., Paterson, N. J.
Halldorson Company, The, 4500 Ravenswood Ave., Chicago 28, Ill.
Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass.
International Transformer Co., 396 Broadway, New York, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Leece-Neville Co., 5363 Hamilton Ave. N.E., Cleveland 14, Ohio
Leland Electric Co., 1501 Webster St., Dayton, Ohio
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Philadelphia Thermometer Co., 6th & Cayuga Sts., Philadelphia, Pa.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radionic Controls, 3758 Belmont Ave., Chicago 18, Ill.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
SOS Cinema Supply Co., 449 West 42nd St., New York 18, N. Y.
Standard Transformer Corp., 1500 N. Halsted St., Chicago, Ill.
Stockwell Transformer Corp., 569 S. Main St., Akron, Ohio
Sundt Engrg. Co., 4757 Ravenswood Ave., Chicago, Ill.
Superior Electric Co., 83 Laurel St., Bristol, Conn.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Technical Products Co., 158 Madison Ave. at Third St., Memphis, Tenn.
Techno-Scientic Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
Transmitter Equipment Mfg. Co., Inc., 345 Hudson St., New York, N. Y.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.
Waugh Labs., Div. of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago 47, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wirt Co., 5221 Greene St., Philadelphia, Pa.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

Relays

CAPACITY OPERATED RELAYS

Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Auth Electrical Specialty Co., Inc., 422 East 53rd St., New York 22, N. Y.
Browning Labs., Inc., 750 Main St., Winchester, Mass.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Federal Instrument Co., 3917-47th Ave., Long Island City, N. Y.
General Electric Co., Schenectady 5, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Price Brothers Co., Frederick, Md.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Sorenson & Co., 375 Fairfield Ave., Stamford, Conn.

HEAVY DUTY RELAYS

Adams & Westlake Co., Michigan St., Elkhart, Ind.
Advance Electric and Relay Co., 1260 W. Second St., Los Angeles, Calif.
Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.
Arrow-Hart & Hegeman Electric Co., 103 Hawthorne St., Hartford 6, Conn.
Autocall Co., 1142 Tucker Ave., Shelby, Ohio
Automatic Electric Co., 1033 West Van Buren St., Chicago 7, Ill.
Automatic Electric Mfg. Co., 10 State St., Mankato, Minn.
Automatic Switch Co., 41 East 11th St., New York 3, N. Y.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Cutler-Hammer, Inc., 315 N. 12th Street, Milwaukee 1, Wisc.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
General Controls Co., 801 Allen Ave., Glendale, Cal.
General Electric Co., Schenectady 5, N. Y.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
H-B Electric Co., 6109 North 21st St., Philadelphia 38, Pa.
Heinze Electric Co., Lowell, Mass.
Johnson Co., E. F., Waseca, Minn.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Kurman Electric Co., 35-18 37th St., Long Island City 1, N. Y.
Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Calif.
Leece-Neville Co., 5363 Hamilton Ave., Cleveland 14, Ohio
Minneapolis-Honeywell Reg. Co., 2753 Fourth Ave., S., Minneapolis, Minn.
Monitor Controller Co., 51 S. Gay St., Baltimore 2, Md.
Price Brothers Co., Frederick, Md.
Philadelphia Thermometer Co., 6th & Cayuga Sts., Philadelphia, Pa.
R. B. M. Mfg. Co., Div. of Essex Wire Corp., Logansport, Ind.
Signal Engineering & Mfg. Co., 154 W. 14th St., New York, N. Y.
Square D Co., 6060 Rivard St., Detroit 11, Mich.
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Tork Clock Co., 1 Grove St., Mt. Vernon, N. Y.
Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

MERCURY RELAYS

Adams & Westlake, Michigan St., Elkhart, Ind.
American Instrument Co., 8030 Georgia Ave., Silver Springs, Md.
Autocall Co., 1142 Tucker Ave., Shelby, Ohio
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Automatic Temperature Control Co., 34 E. Logan St., Philadelphia, Pa.
Brown Instrument Co., 4428 Wayne Ave., Philadelphia, Pa.
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Durakool, Inc., 1010 N. Main St., Elkhart, Ind.
General Electric Co., Schenectady 5, N. Y.
Guardian Electric Mfg. Co., 1400 Washington Blvd., Chicago 7, Ill.
H-B Electric Co., 6109 N. 21st St., Philadelphia 38, Pa.
Hart Mfg. Co., 110 Bartholomew Ave., Hartford 1, Conn.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Philadelphia Thermometer Co., 6th & Cayuga Sts., Philadelphia, Pa.
Precision Thermometer & Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.
Sperti, Inc., Norwood Station, Cincinnati, Ohio
Standard Electrical Products Co., 400 Linden Ave., Dayton 3, Ohio
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.

PHOTOELECTRIC RELAYS

Advance Electric and Relay Co., 1260 W. Second St., Los Angeles, Calif.
Allied Control Co., Inc., 2 East End Avenue, New York 21, N. Y.
American Instrument Co., 8030 Georgia Ave., Silver Springs, Md.
Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Auth Electrical Specialty Co., Inc., 422 East 53rd St., New York 22, N. Y.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Eby, Inc., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Electronic Control Corp., 1573 E. Forest St., Detroit, Mich.
Electronic Laboratory, 306 S. Edinburgh Ave., Los Angeles, Cal.
Electronic Products Co., 19 N. First St., Geneva, Ill.

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Federal Instrument Co., 3917-47th Ave., Long Island City, N. Y.
Fisher-Pierce Co., 80 Ceylon St., Boston, Mass.
General Electric Co., Schenectady 5, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb.
Hatton Co., Arthur T., 410 Asylum St., Hartford, Conn.
Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Cal.
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Parker Engineering Pdts. Co., 16 W. 22nd St., New York 10, N. Y.
Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
Standard Electrical Products Co., 400 Linden Ave., Dayton 3, Ohio.
Technical Products Co., 158 Madison Ave., at Third St., Memphis, Tenn.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
White Research, 899 Boylston St., Boston, Mass.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.

PHOTOTUBE RELAYS

Advance Electric and Relay Co., 1260 W. Second St., Los Angeles, Calif.
Aerolux Light Corp., 653 11th Ave., New York 19, N. Y.
Allied Control Co., Inc., 2 East End Avenue, New York 21, N. Y.
Audio Tone Oscillator Co., 237 John St., Bridgeport 3, Conn.
Auth Electrical Specialty Co., Inc., 422 E. 53rd St., New York 22, N. Y.
Automatic Electric Co., 1033 West Van Buren St., Chicago 7, Ill.
Brown Instrument Co., 4428 Wayne Ave., Philadelphia 44, Pa.
Electronic Control Corp., 1573 E. Forest St., Detroit, Mich.
Electronic Products Co., 19 N. First St., Geneva, Ill.
Federal Instrument Co., 3917-47th Ave., Long Island City, N. Y.
Fisher-Pierce Co., 80 Ceylon St., Boston, Mass.
General Electric Co., Schenectady 5, N. Y.
Hatton Co., Arthur T., 410 Asylum St., Hartford, Conn.
Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Cal.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Parker Engineering Pdts. Co., 16 W. 22nd St., New York 10, N. Y.
Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.
Potter & Brumfield Mfg. Co., Inc., 617-621 No. Gibson St., Princeton, Indiana
Radio Corp. of America, RCA Victor Div., Camden, N. J.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
White Research, 899 Boylston St., Boston, Mass.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.

POLARIZED RELAYS

Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.
Auth Electrcal Specialty Co., Inc., 422 East 53 St., New York 22, N. Y.
Autocall Co., 1142 Tucker Ave., Shelby, Ohio
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Barber-Colman Co., Rockford, Ill.
Bunnell & Co., J. H., 215 Fulton St., New York, N. Y.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
General Electric Co., Schenectady 5, N. Y.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Leece-Neville Co., 5363 Hamilton Ave., Cleveland 14, Ohio
Precision Thermometer & Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.
Price Brothers Co., Frederick, Md.
Signal Engrg. & Mfg. Co., 154 W. 14th St., New York, N. Y.
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Union Switch & Signal Co., Swissvale, Pa.
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
Westinghouse Electrc Corp., East Pittsburgh, Pa.

SENSITIVE CONTROL RELAYS

Advance Electric and Relay Co., 1260 W. Second St., Los Angeles, Cal.
Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.
American Instrument Co., Silver Springs, Md.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Arrow-Hart & Hageman Elec. Co., Hartford, Conn.
Auth Electrical Specialty Co., Inc., 422 E. 53rd St., New York 22, N. Y.
Autocall Co., 1142 Tucker Ave., Shelby, Ohio
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Automatic Electric Mfg. Co., 10 State St., Mankato, Minn.
Automatic Temperature Co., 34 E. Logan St., Philadelphia 44, Pa.
Bank's Mfg. Co., 1105 W. Lawrence Ave., Chicago 40, Ill.
Barber-Colman Co., Rockford, Ill.
Birtcher Corp., 5087 Huntington Drive, Los Angeles 32, Cal.
Bunnell & Co., J. H., 215 Fulton St., New York, N. Y.
Burlington Instrument Corp., 214 North 4th St., Burlington, Iowa
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Cutler-Hammer, Inc., 315 N. 12th Street, Milwaukee 1, Wisc.
Davis & Co., Inc., Dean W., Kentland, Ind.
Dayton Acme Co., 930 York St., Cncinnati, Ohio
Distillation Products, Inc., 755 Ridge Rd., W., Rochester, N. Y.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N. J.
Electric Auto-Lite Co., Toledo 1, Ohio
Electrical Products Supply Co., 1140 Venice Blvd., Los Angeles 15, Calif.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Federal Instrument Co., 3917-47th Ave., Long Island City, N. Y.
G-M Laboratories, Inc., 4313 N. Knox Ave., Chicago, Ill.
General Controls Co., 801 Allen Ave., Glendale, Calif.
General Electric Co., Schenectady 5, N. Y.
Guardian Electric Mfg. Co., 1400 Washington Blvd., Chicago 7, Ill.
H-B Electric Co., 6109 North 21st St., Philadelphia 38, Pa.
Hart Mfg. Co., 110 Bartholomew Ave., Hartford 1, Conn.
Haydon Manufacturing Co., Inc., Forestville, Conn.
Holtzer-Cabot, Signal Division, 400 Stuart St., Boston 17, Mass.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Cal.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Kurman Electric Co., 35-18 37th St., Long Island City 1, N. Y.
Leach Relay Company, 5915 Avalon Blvd., Los Angeles, Calif.
Lewis Electronics, Inc., Los Gatos, Calif.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Magnetic Devices, Inc., Frederick, Md.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Mossman, Inc., Donald P., 612 N. Michigan Ave., Chicago 31, Ill.
Naxon Utilities Corp., 2101-11 W. Walnut St., Chicago 12, Ill.
North Electric Mfg. Co., 501 S. Market St., Galion, Ohio
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Parker Engrg. Products Co., 16 West 22nd St., New York 10, N. Y.
Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.
Potter & Brumfield Mfg. Co., Inc., 617 N. Gibson St., Princeton, Ind.
Precision Thermometer & Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.
Price Brothers Co., Frederick, Md.
R.B.M. Mfg. Co., Div. of Essex Wire Corp., Logansport, Ind.
Radionic Controls, Inc., 3758 Belmont Ave., Chicago 18, Ill.
Remler Co. Ltd., 2101 Bryant St., San Francisco 10, Calif.
Sigma Instruments, Inc., 70 Ceylon St., Boston 21, Mass.
Signal Engrg. & Mfg. Co., 154 W. 14th St., New York, N. Y.
Smith Mfg. Co., Inc., Nathan R., 105 Pasadena Ave., South Pasadena, Cal.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Square D Co., 6060 Rivard St., Detroit 11, Mich.
Standard Electrical Products Co., 400 Linden Ave., Dayton 3, Ohio
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Technical Products Co., 158 Madison Ave., at Third St., Memphis, Tenn.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Wallace & Tiernan Products, Inc., Belleville, N. J.
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
Warrick, Chas. F., 16251 Hamilton Ave., Detroit 3, Mich.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

STEPPING RELAYS

Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.
Autocall Co., 1142 Tucker Ave., Shelby, Ohio
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Connecticut Telephone & Electric Div. of Great American Industries, 70 Brittania St., Meriden, Conn.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Eagle Signal Corp., 202-20th St., Moline, Ill.
Guardian Electric Mfg. Co., 1400 Washington Blvd., Chicago 7, Ill.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
North Electric Mfg. Co., 501 S. Market St., Galion, Ohio
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Price Brothers Co., Frederick, Md.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Signal Engrg. & Mfg. Co., 154 West 14th St., New York, N. Y.
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Union Switch & Signal Co., Swissvale, Pa.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

TELEPHONE RELAYS

Advance Electric and Relay Co., 1260 West Second St., Los Angeles, Calif.

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ELECTRONIC and ALLIED PRODUCTS

Allied Control Co., Inc., 2 East End Ave., New York 10, N. Y.
Auth Electrical Specialty Co., Inc., 422 East 53rd St., New York 22, N. Y.
Autocall Co., 1142 Tucker Ave., Shelby, Ohio
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.
G-M Laboratories, Inc., 4313 N. Knox Ave., Chicago, Ill.
Guardian Electric Mfg. Co., 1400 Washington Blvd., Chicago 7, Ill.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kurman Electric Co., 35-18 37th St., Long Island City 1, N. Y.
Lake Mfg. Co., 2323 Chestnut St., Oakland 7, Calif.
Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Calif.
Leich Electric Co., 565 W. Washington Blvd., Chicago 6, Ill.
Magnetic Devices Inc., Frederick, Md.
Maico Co. Inc., 25 North 3rd St., Minneapolis, Minn.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
North Electric Mfg. Co., 501 S. Market St., Galion, Ohio
Parker Engineering Products Co., 16 West 22nd St., New York 10, N. Y.
Potter & Brumfield Mfg. Co., Inc., 617 N. Gibson St., Princeton, Ind.
Price Brothers Co., Frederick, Md.
R.B.M. Mfg. Co., Div. of Essex Wire Corp., Logansport, Ind.
Radionic Controls, Inc., 3758 Belmont Ave., Chicago 18, Ill.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Signal Engrg. & Mfg. Co., 154 West 14th St., New York, N. Y.
Standard Electrical Products Co., 400 Linden Ave., Dayton 3, Ohio
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Western Electro-Mechanical Co., Inc., 300 Broadway, Oakland, Calif.

TIME DELAY RELAYS

Adams & Westlake Co., Michigan St., Elkhart, Ind.
Advance Electric and Relay Co., 1260 W. Second St., Los Angeles, Calif.
Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.
American Gas Accumulator Co., 1029 Newark Ave., Elizabeth, N. J.
Amperite Co., 561 Broadway, New York, N. Y.
Auth Electrical Specialty Co., Inc., 422 East 53rd St., New York 22, N. Y.
Autocall Co., 1142 Tucker Ave., Shelby, Ohio
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Automatic Temperature Control Co., 34 E. Logan St., Philadelphia 44, Pa.
Betts & Betts Corp., 551 West 52nd St., New York, N. Y.
Burlington Instrument Corp., 214 North 4th St., Burlington, Iowa
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Clark Controller Co., 1146 E. 152nd St., Cleveland, Ohio
Cook Electric Co., 2700 Southport Ave., Chicago, Ill.
Cramer Co., R. W., Centerbrook, Conn.
Curtis Development & Mfg. Co., 1 N. Crawford Ave., Chicago 24, Ill.
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Dayton Acme Co., 930 York St., Cincinnati, Ohio
Eagle Signal Corp., Moline, Ill.
Edison, Inc., Thomas A., Instrument Div., 51 Lakeside Ave., West Orange, N. J.
Electrical Products Supply Co., 1140 Venice Blvd., Los Angeles 15, Calif.
Electronic Products Co., 19 North First St., Geneva, Ill.
General Control Co., 1200 Soldiers Field Rd., Boston 34, Mass.
General Electric Co., Schenectady 5, N. Y.
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wisc.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Guardian Electric Mfg. Co., 1400 Washington Blvd., Chicago 7, Ill.
H-B Electric Co., 6109 North 21st St., Philadelphia 38, Pa.
Haydon Manufacturing Co., Inc., Forestville, Conn.
Holtzer-Cabot Signal Division, 400 Stuart St., Boston 17, Mass.
Industrial Timer Corp., 117 Edison Pl., Newark 5, New Jersey
Kurman Electric Co., 35-18 37th St., Long Island City 1, N. Y.
Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Calif.
Luers, J. Milton, 12 Pine St., Mt. Clemens, Mich.
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Magnetic Devices, Inc., Frederick, Md.
Magnetic Gauge Co., 60 E. Bartges St., Akron, Ohio
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Monitor Controller Co., 51 S. Gay St., Baltimore 2, Md.
New Haven Clock Co., New Haven 4, Conn.
North Electric Mfg. Co., 501 S. Market St., Galion, Ohio
Paragon Electric Co., 37 W. Van Buren St., Chicago 5, Ill.
Partlow Corp., 2 Campion Rd., New Hartford, N. Y.
Philharmonic Radio Corp., 528 . 72nd St., New York 21, N. Y.
Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y.
Precision Thermometer & Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.
Price Brothers Co., Frederick, Md.
R. B. M. Mfg. Co., Div., of Essex Wire Corp., Logansport, Ind.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Reliance Automatic Lighting Co., 1920 Mead St., Racine, Wisc.
Reynolds Electric Co., 2650 W. Congress St., Chicago 12, Ill.
Rhodes, Inc., M. H., 30 Bartholomew Ave., Hartford, Conn.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Sigma Instruments, Inc., 70 Ceylon St., Boston 21, Mass.
Signal Engrg. & Mfg. Co., 154 W. 14th St., New York, N. Y.
Sorenson & Co., 375 Fairfield Ave., Stamford, Conn.
Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.
Springfield Sound Co., Electronics Division, 12 Cass St., Springfield, Mass.
Square D Co., 6060 Rivard St., Detroit 11, Mich.
Standard Electrical Products Co., 400 Linden Ave., Dayton 3, Ohio
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Ulanet Co., George, 88 E. Kinney St., Newark 5, N. J.
Union Switch & Signal Co., Swissvale, Pa.
United Cinephone Corp., 65 New Litchfield, Torrington, Conn.
Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio
Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
White-Rodgers Electric Co., 1209 Cass Ave., St. Louis, Mo.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

VACUUM CONTACT RELAYS

Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, North Hollywood, Calif.
Edison, Inc., Thomas A., Instrument Div., 51 Lakeside Ave., W. Orange, N. J.
Eitel-McCullough, Inc., San Bruno, Calif.
General Electric Co., Schenectady 5, N. Y.
H-B Electric Co., 6109 N. 21st St., Philadelphia 38, Pa.
Industrial & Commercial Electronics, Belmont, Calif.
Monitor Controller Co., 51 S. Gay St., Baltimore 2, Md.
Price Brothers Co., Frederick, Md.
R.B.M. Mfg. Co. Div. of Essex Wire Corp., Logansport, Ind.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Signal Engineering & Mfg. Co., 154 West 14 St., New York, N. Y.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio

Repairs, Tube

see Tube Repairs

Resistors

FIXED RESISTORS

Acme Electric Heating Co., 1217 Washington St., Boston, Mass.
Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Atlas Resistor Co., 423 Broome St., New York, N. Y.
Carborundum Co., Globar Div., Niagara Falls, N. Y.
Cinema Engineering Co., 1508 W. Verdugo Ave., Burbank, Calif.
Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn 1, N. Y.
Continental Carbon Inc., 13900 Lorain Ave., Cleveland, Ohio
Cutler-Hammer, Inc., 315 North 12th Street, Milwaukee 1, Wisc.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Electric Service Manufacturing Co., 17th & Cambria Sts., Philadelphia 32, Pa.
Erie Resistor Corp., 644 W. 12 St., Erie, Pa.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Globar Div., Carborundum Co., Buffalo Ave., Niagara Falls, N. Y.
Instrument Resistors Co., Little Falls, N. J.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Madison Electrical Products Corp., Madison, N. J.
Mallory & Co., Inc., P. R. 3029 E. Washington St., Indianapolis, Ind.
Monitor Controller Co., 51 S. Gay St., Baltimore 2, Md.
Muter Co., 1255 S. Michigan Ave., Chcago, Ill.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Ohio Carbon Co., 12508 Berea Rd., Cleveland Ohio
Ohmite Manufacturing Co., 4835 W. Flournoy St., Chicago, Ill.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Precision Machine Works Inc., 14 South Ninth St., Minneapolis, Minn.
Precision Resistor Co., 334 Badger Ave., Newark 8, N. J.
Rex Rheostat Co., 3 Foxhurst Rd., Baldwin, N. Y.
Schaefer Bros. Co., 1059 W. 11th St., Chicago, Ill.
Shallcross Mfg. Co., 10 Jackson Ave., Collingsdale, Pa.
Speer Resistor Corp., St. Marys, Pa.
Sprague Electric Co., North Adams, Mass.
Stackpole Carbon Co., Tannery St., St. Marys, Pa.
States Co., 19 New Park Ave., Hartford 6, Conn.
Trefz Mfg. Co., 28-11 Main St., Flushing, N. Y.
Tuttle & Co., H. W., 261 W. Maumee St., Adrian, Mich.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio

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Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
White Dental Manufacturing Co., S. S. (Industrial Div.) 10 E. 40th St., New York, N. Y.
Wirt Co., 5221 Greene St., Philadelphia, Pa.
Wright Machine & Tool Corp., 7 West 30th St., New York 1, N. Y.

VARIABLE RESISTORS
POTENTIOMETERS and RHEOSTATS

A. B. C. Products, Inc., 11952 Montana Ave., W. Los Angeles, Calif.
Acme Electric Heating Co., 1217 Washington St., Boston, Mass.
Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wis.
Atlas Resistor Co., 423 Broome St., New York, N. Y.
Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, O.
Biddle Co., James G., 1213 Arch St., Philadelphia, Pa.
Bristol Co., Waterbury 91, Conn.
Brown Instrument Co., 4428 Wayne Ave., Philadelphia 44, Pa.
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Centralab Div. of Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Central Scientific Co., 1700 Irving Park Blvd., Chicago 13, Ill.
Chicago Apparatus Co., 1735 N. Ashland Ave., Chicago, Ill.
Chicago Telephone Supply Co., 1142 W. Beardsley Ave., Elkhart, Ind.
Cinema Engineering Co., 1508 W. Verdugo Ave., Burbank, Calif.
Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn, N. Y.
Columbia Electric Mfg. Co., 4519 Hamilton Ave., N. E., Cleveland 14, Ohio
Curtis Development & Mfg. Co., 1 N. Crawford Ave., Chicago 24, Ill.
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Daven Co., 191 Central Ave., Newark 4, N. J.
DeJur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Eagle Electric Mfg. Co. Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Eastern Specialty Co., 3619 N. Eighth St., Philadelphia 40, Pa.
Electronic Products Co., 19 N. First St., Geneva, Ill.
Fairchild Camera & Instrument Corp., 475 Tenth Ave., New York 18, N. Y.
General Electric Co., Schenectady 5, New York
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Giannini & Co., Inc., G. M., 161 E. California St., Pasadena, Calif.
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wisc.
Gilbert Clock Co., Wm. L., Winsted, Conn.
Gray Instrument Co., 64½ W. Johnson St., Philadelphia, Pa.
Hardwick, Hindle, Inc., 40 Hermon St., Newark, N. J.
Helipot Corp., 1011 Mission St., South Pasadena, Calif.
Hewlett Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Lectrohm, Inc., 5125 W. 25th St., Cicero 50, Ill.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Madison Electrical Prods. Corp., Madison, N. J.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Morganite Brush Co., 33-02 48th Ave., Long Island City, N. Y.
Mossman, Inc., Donald P., 612 N. Michigan Ave., Chicago 11, Ill.
National Electric Controller Co., 5307 Ravenswood Ave., Chicago, Ill.
Ohio Carbon Co., 12508 Berea Rd., Cleveland, Ohio
Ohmite Manufacturing Co., 4835 W. Flournoy St., Chicago 44, Ill.
Presto Electric Co., 4511 New York Ave., Union City, N. J.
Rex Rheostat Co., 3 Foxhurst Rd., Baldwin, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rowe Radio Research Laboratory Co., 2422 N. Pulaski Rd., Chicago 39, Ill.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Schaefer Bros. Co., 1059 W. 11th St., Chicago, Ill.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Speer Carbon Co., St. Marys, Pa.
Stackpole Carbon Co., St. Marys, Pa.
Sticht Co., Inc., Herman H., 27 Park Place, New York 7, N. Y.
Tech Laboratories, 7 Lincoln St., Jersey City, N. J.
Thwing-Albert Instrument Co., Penn St., & Pulaski Ave., Philadelphia 44, Pa.
Trefz Mfg. Co., 38-11 Main St., Flushing, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wirt Co., 5221 Greene St., Philadelphia, Pa.
Wright Machine & Tool Corp., 7 West 30th St., New York, N. Y.

WIRE WOUND RESISTORS

Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
Associated Research, Inc., 231 S. Green St., Chicago, Ill.
Atlas Resistor Co., 423 Broome St., New York, N. Y.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Centralab Div. of Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wis.
Cinema Engineering Co., 1508 W. Verdugo Ave., Burbank, Calif.
Clarostat Mfg. Co., 130 Clinton St., Brooklyn, N. Y.
Continental Carbon, Inc., 13900 Lorain Ave., Cleveland, Ohio
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Daven Co., 191 Central Ave., Newark 4, N. J.
DeJur-Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Eagle Electric Mfg. Co., Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Elco Resistors Co., 112 W. 18th St., New York, N. Y.
Electrical Reactance Corp., Franklinville, N. Y.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wisc.
Gilbert Clock Co., Wm. L., Winsted, Conn.
Groves Corporation, Cape Girardeau, Mo.
Hardwick Hindle, Inc., 40 Hermon St., Newark, N. J.
Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.
Instrument Resistors Co., 25 Amity St., Little Falls, N. J.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Lecthrohm, Inc., 5125 W. 25th St., Cicero, 50, Ill.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Madison Electrical Products Corp., Madison, N. J.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Marion Electrical Instrument Co., Manchester, N. H.
Micamold Radio Corp., 1087 Flushing Ave., Brooklyn 6, N. Y.
Monitor Controller Co., 51 S. Gay St., Baltimore 2, Md.
Muter Co., 1255 S. Michigan Ave., Chicago, Ill.
National Electric Controller Co., 5307 Ravenswood Ave., Chicago, Ill.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Nilsson Electrical Laboratory, Inc., 102 Lafayette St., New York 13, N. Y.
Ohio Carbon Co., 12508 Berea Rd., Cleveland, Ohio
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago 44, Ill.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Precision Machine Works, Inc., 14 South Ninth St., Minneapolis, Minn.
Precision Resistor Co., 334 Badger Ave., Newark 8, N. J.
Presto Electric Co., 4511 New York Ave., Union City, N. J.
Reimers Electric Appliance Co., Inc., 596-56th St., West New York, N. J.
Rex Rheostat Co., 3 Foxhurst Rd., Baldwin, N. Y.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Schaefer Bros. Co., 1059 W. 11th St., Chicago, Ill.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Sprague Electric Co., North Adams, Mass.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Techno-Scientific Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
Trefz Mfg. Co., 38-11 Main St., Flushing, N. Y.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Ward Leonard Electric Co., 31 South St., Mount Vernon, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wirt Co., 5221 Greene St., Philadelphia, Pa.
Wright Machine & Tool Corp., 7 West 30th St., New York, N. Y.

Rheostats

see Variable Resistors

Rings, Oil Sealing

Auburn Mfg. Co., 110 Stack St., Middletown, Conn.
Graphite Metallizing Corp., 1055 Nepperhan Ave., Yonkers 3, N. Y.
Sealol Corp., 45 Willard St., Providence, R. I.

Rings, Retaining

Waldes Kohinoor, Inc., Long Island City 1, N. Y.

Rivets

American Brass Co., Waterbury 88, Conn.
Atlas Tack Corp., Pleasant St., Fairhaven, Mass.
Blake & Johnson Co., 1495 Thomaston Ave., Waterville, Conn.
Central Screw Co., 3511 Shields Ave., Chicago 9, Ill.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Cherry Rivet Co., 231 Winston St., Los Angeles 13, Calif.
Chicago Rivet & Machine Co., 9600 W. Jackson Blvd., (Bellwood) Chicago, Ill.
Clark Bros. Bolt Co., Milldale, Conn.
Clendenin Bros., 108 South St., Baltimore, Md.
Cobb & Drew, Kingston St., Plymouth, Mass.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
Harper Co., H. M., 2630 Fletcher St., Chicago 18, Ill.
Hassall Inc., John, Clay & Oakland Sts., Brooklyn, N. Y.

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ELECTRONIC and ALLIED PRODUCTS

Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Johnson Co. E. F., Waseca, Minn.
Lamson & Sessions Co., 1971 West 85th St., Cleveland, Ohio
Manufacturer's Belt Hook Co., 1321 W. Congress St., Chicago, Ill.
Manufacturers' Screw Products, 270 W. Hubbard St., Chicago, Ill.
Milford Rivet & Machine Co., Milford, Conn. (Eastern Div.), Elyria, Ohio (Central Div.)
National Screw & Mfg. Co., 2440 E. 75th St., Cleveland 4, Ohio
New England Screw Co., Keene, N. H.
Plume & Atwood Mfg. Co., 470 Bank St., Waterbury, Conn.
Progressive Mfg. Co., 52 Norwood St., Torrington, Conn.
Reed & Prince Mfg. Co., Duncan Ave., Worcester, Mass.
Russell, Burdsall & Ward Bolt & Nut Co., Midland Ave., Port Chester, N. Y.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Stimpson Co., Inc., Edwin B., 74 Franklin Ave., Brooklyn 5, N. Y.
Tubular Rivet & Stud Co., Wollaston 70, Mass.

Rubber Insulating Compounds

see Waxes

Saws Crystal

see Crystal Finishing Equipment

Scales

DIAL SCALES

see also Dials
also Escutcheons

American Insulator Corp., New Freedom, Pa.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Austin Co., O., 42 Greene St., New York, N. Y.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bastian Bros. Co., 1600 N. Clinton Ave., Rochester, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Cardy-Lundmark Co., 1801 W. Byron St., Chicago 13, Ill.
Chatillon & Sons, John, 85-93 Cliff St., New York, N. Y.
Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
Etched Products Corp., 3901 Queens Blvd., Long Island City, N. Y.
Emeloid Co., Inc., 291 Laurel Ave., Arlington, N. J.
Felsenthal & Sons, G., 4122 W. Grand Ave., Chicago 51, Ill.
Finch Telecommunications, Inc., Passaic, N. J.
Gemloid Corp., 79-10 Albion Ave., Elmhurst, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
Grammes & Sons, Inc., L. F., 389 Union St., Allentown 2, Pa.
Hopp Press, Inc., 460 West 34th St., New York, N. Y.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
New England Etching & Plating Co., 25 Spring St., Holyoke, Mass.
New England Radiocrafters, 1156 Commonwealth Ave., Boston 34, Mass.
Parisian Novelty Co., 3510 S. Western Ave., Chicago 9, Ill.
Plastic Fabricators Co., 440 Sansome St., San Francisco 11, Calif.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.

Screws

RECESSED HEAD SCREWS

Allen Mfg. Co., Hartford, Conn.
American Screw Co., Providence, R. I.
Atlantic Screw Works, Hartford, Conn.
Bristol Co., Waterbury 91, Conn.
Central Screw Co., 3511 Shields Ave., Chicago 9, Ill.
Chandler Products Co., 1475 Chardon Rd., Cleveland, Ohio
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Continental Screw Co., New Bedford, Mass.
Corbin Screw Corp., High, Myrtle & Grove Sts., New Britain, Conn.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
General Screw & Mfg. Co., 1228 W. Monroe St., Chicago 7, Ill.
Harper Co., H. M., 2620 Fletcher St., Chicago 18, Ill.
Hartford Machine Screw Co., Hartford, Conn.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 25, Ill.
International Screw Co., 9444 Roselawn Ave., Detroit, Mich.
Lamson & Sessions Co., 1971 W. 85th St., Cleveland, Ohio
Manufacturers Screw Products, 270 W. Hubbard St., Chicago, Ill.
Milford Rivet & Machine Co., Milford, Conn.
National Screw & Mfg. Co., 2440 E. 75th St., Cleveland 4, Ohio
Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., 5700 Roosevelt Rd., Chicago 50, Ill.
Reading Screw Co., Norristown, Pa.
Reed & Prince Mfg. Co., Duncan Ave., Worcester, Mass.
Russell, Burdsall & Ward Bolt & Nut Co., Midland Ave., Port Chester, N. Y.
Scovill Mfg. Co., Waterbury 91, Conn.
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago 39, Ill.
Southington Hdwe. Mfg. Co., Southington, Conn.
St. Louis Screw & Bolt Co., 6900 N. Broadway, St. Louis 15, Mo.
Sterling Bolt Co., 209 W. Jackson Blvd., Chicago, Ill.
United Screw & Bolt Corp., 2513 W. Cullerton St., Chicago, Ill.
Whitney Screw Co., Nashua, N. H.
Wolverine Bolt Co., Detroit, Mich.

SET and CAP SCREWS

Allen Mfg. Co., Hartford, Conn.
Bristol Co., Waterbury 91, Conn.
Chandler Products Corp., 1475 Chardon Rd., Cleveland, Ohio
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Continental Screw Co., New Bedford, Mass.
Corbin Screw Corp., High, Myrtle & Grove Sts., New Britain, Conn.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Harper Co., H. M., 2620 Fletcher St., Chicago 18, Ill.
Hartford Machine Screw Co., Hartford, Conn.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Lamson & Sessions Co., 1971 W. 85th St., Cleveland, Ohio
Manufacturers Screw Products, 270 W. Hubbard St., Chicago, Ill.
National Screw & Mfg. Co., 2440 E. 75th St., Cleveland 4, Ohio
Parker-Kalon Corp., 200 Varick St., New York 14, N. Y.
Pheoll Manufacturing Co., 5700 Roosevelt Rd., Chicago 50, Ill.
Reed & Prince Mfg. Co., Duncan Ave., Worcester, Mass.
Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio
Russell, Burdsall & Ward Bolt & Nut Co., Midland Ave., Port Chester, N. Y.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Scovill Mfg. Co., 99 Mill St., Waterbury, 91, Conn.
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago 39, Ill.
St. Louis Screw & Bolt Co., 6900 B'way, St. Louis 15, Mo.
Standard Pressed Steel Co., Jenkintown, Pa.
Sterling Bolt Co., 209 W. Jackson Blvd., Chicago, Ill.

SPECIAL SCREWS

Ericsson Screw Machine Products Co., Inc., 25 Lafayette St., Brooklyn 1, N. Y.
New England Screw Co., Keene, N. H.
Progressive Mfg. Co., Torrington, Conn.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Waltham Screw Co., 77 Rumford Ave., Waltham, Mass.
White Dental Mfg. Co., S. S. Industrial Div., 10 East 40th St., New York, N. Y.

Seals, Hermetic

Aerolux Light Corp., 653 Eleventh Ave., New York 19, N. Y.
Cincinnati Electric Products Co., Carthage at Hannaford, Cincinnati 12, Ohio
Dongan Electric Mfg. Co., 2987 Franklin St., Detroit, Mich.
Electrical Industries, Inc., 42 Summer Ave., Newark 4, N. J.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Federal Electric Co., Inc., 8700 S. State St., Chicago 19, Ill.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
General Ceramics & Steatite Corp., Keasbey, N. J.
H-B Electric Co., 6109 North 21st St., Philadelphia 38, Pa.
Hermaseal Co., Riverside Drive, Elkhart, Indiana
Kopp Glass Inc., 1 East 42nd Street, New York 17, N. Y.
Marion Electrical Instrument Co., Manchester, N. H.
Mycalex Corp. of America, 60 Clifton Blvd., Clifton, N. J.
Pacific Clay Products Co., 306 West Avenue 26, Los Angeles 31, Calif.
Radio Frequency Labs., Inc., Boonton, N. J.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Universal X-Ray Products, Inc., 1800 North Francisco Ave., Chicago 47, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Selsyns

Diehl Mfg. Co., Finderne Plant, Somerville, N. J.
Electric Engineering & Mfg. Co., Los Angeles, Calif.
Electric Indicator Co., 21 Parker Ave., Stamford, Conn.
Electric Specialty Co., 211 South Street, Stamford, Conn.
Electrical Engineering & Mfg. Corp., 4606 W. Jefferson Blvd., Los Angeles 16, Calif.
Electroiux Corp., Old Greenwich, Conn.
Electromatic Typewriters, Inc., Rochester, N. Y.
General Electric Co., Fort Wayne, Ind.
General Electric Co., Schenectady 5, N. Y.
Hobart Mfg. Co., Troy, Ohio
Philharmonic Radio Corp., 528 E. 72nd St., New York 21, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Servos, Solenoid & Plunger

American Television & Radio Co., 300 E. Fourth St., St. Paul 1, Minn.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
Lear, Inc., Piqua, Ohio
Reeves Sound Lab., Inc., 62 West 47th St., New York, N. Y.
Sperti, Inc., Norwood Sta., Cincinnati, Ohio
Westinghouse Electric Corp., East Pittsburgh, Pa.

Shafts

FLEXIBLE SHAFTS

Breeze Corp., 41 S. Sixth St., Newark, N. J.

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Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Haskins Co., R. G., 615 S. California Ave., Chicago 12, Ill.
Invincible Tool Co., 611 Empire, Pittsburgh 22, Pa.
J. F. D. Mfg. Co., 4111 Ft. Hamilton Pkwy, Brooklyn, N. Y.
Lear Incorporated, Piqua, Ohio
Linick & Co., Leslie L., 29 E. Madison St., Chicago, Ill.
Martindale Electric Co., 1371 Hird Ave., Cleveland, Ohio
Pratt & Whitney Div. Niles-Bement-Pond Co., West Hartford 1, Conn.
Stewart Mfg. Corp., F. W., 4311 Ravenswood Ave., Chicago 13, Ill.
Stow Mfg. Co., 445 State St., Binghamton, N. Y.
Walker-Turner Co. Inc., 1463 Berckman St., Plainfield, N. J.
White Dental Mfg. Co., S. S. Industrial Div., 10 E. 40th St., New York, N. Y.

Shields

TUBE SHIELDS

Allegheny Ludlum Steel Corp., Brackenridge, Pa.
Aluminum Goods Mfg. Co., Manitowoc, Wisc.
American Brass Co., Waterbury 88, Conn.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway, S., Mt. Vernon, N. Y.
Bud Radio, Inc., 2118 East 55th St., Cleveland 3, Ohio
Erie Can Co., 816 W. Erie St., Chicago, Ill.
Franklin Mfg. Corp., A. W., 175 Varick St., New York, N. Y.
Goat Metal Stampings, Inc., 314 Dean St., Brooklyn, N. Y.
Gits Molding Corp., 4600 Huron St., Chicago, Ill.
Guthman & Co., Edwin I., 15 S. Throop St., Chicago, Ill.
Hegeler Zinc Co., Danville, Ill.
J. F. D. Mfg. Co., 4111 Ft. Hamilton Parkway, Brooklyn, N. Y.
Johnson Co., E. F., Waseca, Minn.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
Paul & Beekman, 18th & Cortland Sts., Philadelphia, Pa.
Rice's Sons, Inc., Bernard, 325 Fifth Avenue, New York 16, N. Y.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Union Aircraft Products Corp., 380 Second Ave., New York, N. Y.

Shunts

AMMETER SHUNTS

Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Avia Products Co., 7266 Beverly Blvd., Los Angeles 36, Calif.
Boes Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
Burlington Instrument Corp., 214 North 4th St., Burlington, Iowa
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis, Ind.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Electronics Mfg. Co., 2225 So. Hoover St., Los Angeles 7, Calif.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Instrument Resistors Co., 25 Amity St., Little Falls, N. J.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia, Pa.
Marion Electrical Instrument Co., Manchester, N. H.
Meters, Inc., 915 Riveria Drive, Indianapolis 5, Ind.
Norton Electrical Instrument Co., 79 Hilliard St., Manchester, Conn.
Precision Resistor Co., 334 Badger Ave., Newark 8, N. J.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Roller-Smith, Bethlehem, Pa.
Scientific Service Laboratories, 2225 So. Hoover St., Los Angeles 7, Calif.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sun Mfg. Co., 6623 Avondale Ave., Chicago, Ill.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Westinghouse Electrical Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Freylinghuysen Ave., Newark 5, N. J.

Sleeves and Tubes, Cathode

General Plate Div., Metals & Controls Corp., 34 Forest St., Attleboro, Mass. (seamless tubing)
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton 5, N. J.
Precision Laboratories, Inc., Irvington, N. J. (lockseam type)
Precision Tube Co., 3828 Terrace St., Philadelphia 28, Pa.
Radio Corp. of America, RCA Victor Div., Camden, N. J. (lockseam type)
Superior Tube Co., Norristown, Pa. (lapseam, lockseam, seamless type)
Swedish Iron & Steel Corp., 17 Battery Place, New York, N. Y.
Westinghouse Electrical Corp., East Pittsburgh, Pa.

Sockets

DIAL LIGHT SOCKETS

Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway S., Mt. Vernon, N. Y.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Dial Light Co. of America, 900 Broadway, New York 3, N. Y.
Drake Mfg. Co., 1713 Hubbard St., Chicago, Ill.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
Franklin Mfg. Co., A. W., 175 Varick St., New York, N. Y.
General Electric Co., Bridgeport, Conn.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Kirkland Co., H. R., 8-10 King St., Morristown, N. J.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Scovill Mfg. Co., 99 Mill St., Waterbury, Conn.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.
Wood Electric Co., Inc., 826 Broadway, New York 3, N. Y.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

TUBE SOCKETS

Alden Products Co., 117 North Main St., Brockton 64, Mass.
American Brass Co., Waterbury 88, Conn.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway, S., Mt. Vernon, N. Y.
Automatic Metal Prods. Corp., 315 Berry St., Brooklyn, N. Y.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Cinch Mfg. Co., 2335 W. Van Buren St., Chicago, Ill.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Eby, Inc., H. H., 18 W. Chelton Ave., Philadelphia 13, Penn.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Electronic Products Co., North First St., Geneva, Ill.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
Federal Manufacturing & Engrg. Corp., 199 Steuben St., Brooklyn, N. Y.
Franklin Mfg. Corp., W., 175 Varick St., New York, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Schenectady 5, N. Y.
Hammarlund Mfg. Co., Inc., 460 West 34th St., New York 1, N. Y.
Hubbell, Inc., Harvey, Bridgeport 2, Conn.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Johnson Co., E. F., Waseca, Minn.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
Mykroy, Inc., 1917 N. Springfield Ave., Chicago 47, Ill.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
National Fabricated Products, 2650 Belden Ave., Chicago 47, Ill.
National Tile Co., 1200 East 26th St., Anderson, Ind.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Precision Specialties, 220 No. Western Ave., Los Angeles, Calif.
Radio Corp. of America, Tube Div., RCA Harrison, N. J.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Cal.
Standard Winding Corp., 44-62 Johnes St., Newburgh, N. Y.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Solder

Allen Co., Inc., L. B., 6730 Bryn Mawr Ave., Chicago 31, Ill.
Alpha Metals, Inc., 363 Hudson Ave., Brooklyn 1, N. Y.
American Brass Co., Waterbury 88, Conn.
Belmont Smelting & Refining Works, Inc., 330 Belmont Ave., Brooklyn 7, N. Y.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Division Lead Co., 836 W. Kinzie St., Chicago 22, Ill.
Dunton Co., M. W., 670 Eddy St., Providence 3, R. I.
Eutetic Welding Alloys Co., 40 Worth St., New York, N. Y.
Gardiner Metal Co., 4820 S. Campbell Ave., Chicago 32, Ill.
General Electric Co., Bridgeport, Conn.
General Plate Div., Metals & Control Corp., 34 Forest St., Attleboro, Mass.
Glaser Lead Co., Inc., 31 Wycoff Ave., Brooklyn, N. Y.
Goldsmith Bros. Smelting & Refining Co., 58 East Washington St., Chicago, Ill.
Handy & Harman, 82 Fulton St., New York 7, N. Y.
Industrial Screw & Supply Co., 745 W. Lake St., Chicago 6, Ill.
Kester Solder Co., 4212 Wrightwood Ave., Chicago 39, Ill.
Lenk Mfg. Co., Newton Lower Falls, Mass.
Makepeace Co., D. E., Attleboro, Mass.
National Lead Co., 111 Broadway, New York 6, N. Y.
New York Solder Co., 15 Crosby St., New York, N. Y.
Ruby Chemical Co., 68 McDowell St., Columbus 1, Ohio
Westinghouse Electric Corp., East Pittsburgh, Pa.

Solder Flux

see Flux, Solder

Soldering Irons

see Irons, Solder

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ELECTRONIC and ALLIED PRODUCTS

Soldering Pots

see Pots, Soldering

Sound

COMPLETE SOUND SYSTEMS

Altec Lansing Corp., 1680 N. Vine St., Los Angeles 28, Cal.
American Radio Co., 611 E. Garfield Ave., Glendale, Calif.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Atlas Sound Corp., 1443 39th St., Brooklyn, N. Y.
Banks Mfg. Co., 1105 W. Lawrence Ave., Chicago 40, Ill.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bell Sound Systems, Inc., 1183 Essex Ave., Columbus, Ohio
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago, Ill.
Bogen Co., David, 663 Broadway, New York 12, N. Y.
Bond Products Co., 13139 Hamilton Ave., Detroit, Mich.
Boom Electric Amplifier Corp., 1227 W. Washington Blvd., Chicago, Ill.
Carillitone Mfg. Corp., 30 N. Penn St., York, Pa.
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Dilks, Inc., Norwalk, Conn.
Eastern Amplifier Corp., 794 East 140th St., Bronx 54, N. Y.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eckstein Radio & Television Co., 914 LaSalle Ave., Minneapolis 2, Minn.
Electronic Sound Engineering Co., 109 N. Dearborn St., Chicago 2, Ill.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Executone, Inc., 415 Lexington Ave., New York 17, N. Y.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
Gibson, Inc., 225 Parsons St., Kalamazoo, Mich.
Globe Phone Mfg. Corp., 2 Linden St., Reading, Mass.
Godfrey Mfg. Co., 171 S. 2nd St., Milwaukee 4, Wisc.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Neb.
Guided Radio Corp., 161 Sixth Ave., New York 13, N. Y.
Halstead Traffic Communications Corp., 155 East 44th St., New York, N. Y.
Harris Mfg. Co., 2422 W. Seventh St., Los Angeles 5, Calif.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
Hofmann Corp., C. L., 436 Boulevard of the Allies, Pittsburgh, Pa.
Holtzer-Cabot Signal Div., 400 Stuart St., Boston 17, Mass.
Hudson American Corp., 25 W. 43rd St., New York, N. Y.
Industrial Sound Products Co., 3597 Mission St., San Francisco, Calif.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Langevin Co., Inc., 37 W. 65th St., New York, N. Y.
Laurehk Radio Mfg. Co., 3931 Monroe Ave., Wayne, Mich.
Lifetime Sound Equipment Co., 1101 Adams St., Toledo, Ohio
Lincrophone Co., 1661 Howard Ave., Utica, N. Y.
Maico Co., Inc., 25 North 3rd St., Minneapolis, Minn.
Meck Industries, John, Liberty St., Plymouth, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meissner Mfg. Co., Div. Maguire Industries, Mt. Carmel, Ill.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Minerva Corp. of America, 238 William St., New York 7, N. Y.
National Inter-Communicating Systems, 2434 Montrose Ave., Chicago 18, Ill.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Newcomb Audio Products Co., 2815 S. Hill St., Los Angeles 18, Calif.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Operadio Mfg. Co., St. Charles, Ill.
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Pacific Sound Equipment Co., 1534 Cahuenga Blvd., Hollywood, Calif.
Philco Corp., Tioga & "C" Sts., Philadelphia 34, Pa.
Powers Electronic & Communication Co., Inc., Glen Cove, N. Y.
Racon Electric Co., Inc., 52 E. 19th St., New York 3, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Laboratories, Inc., 2701 California Ave., Seattle 6, Wash.
Radio Receptor Co., 251 West 19th St., New York 11, N. Y.
Radolek Co., 601 W. Randolph St., Chicago 6, Ill.
Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.
Record-O-Pox, Inc., 721 N. Martel Ave., Hollywood 46, Calif.
Regal Electronics Corp., 20 West 20 St., New York, N. Y.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Remler Co., 2101 Bryant St., San Francisco 10, Calif.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Riggs & Jeffreys, Inc., 73 Winthrop St., Newark 4, N. J.
Robinson Houchin Optical Co., Radiotone Div., Columbus, Ohio
Rosen & Co., Raymond, 32nd & Walnut Sts., Philadelphia 4, Pa.
Ruby Electric Co., 729 Seventh Ave., New York, N. Y.
S. O. S. Cinema Supply Corp., 449 West 42nd St., New York, N. Y.
Schulmerich Electronics Co., Sellersville, Pa.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Setchell Carlson, Inc., 2233 University Ave., St. Paul 4, Minn.
Sheridan Electronics Corp., 2850 S. Michigan Ave., Chicago, Ill.
Simpson Mfg. Co., Inc., Mark, 188 W. Fourth St., New York, N. Y.
Sound Equipment Corp. of California, 3903 San Fernando Road, Glendale 4, Calif.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
Stark Sound Engrg. Corp., Box 493, Fort Wayne 1, Ind.
Stromberg-Carlson Co., 100 Carlson Rd., Rochester, N. Y.
Taybern Equipment Co., 120 Greenwich St., New York 6, N. Y.
Tech-Master Products Co., 123 Prince St., New York, N. Y.
Waters Conley Co., 501 First St., N. W., Rochester, Minn.
Webster Electric Co., 1900 Clark St., Racine, Wisc.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Western Sound & Electric Laboratories, 3512 W. St. Paul Ave., Milwaukee, Wisc.

Sound Recorders

see Recorders, Sound

Speakers

see Loudspeakers

Springs

Accurate Spring Mfg. Co., 3811 W. Lake St., Chicago, Ill.
All-Weather Springs, 140 Cedar St., New York 6, N. Y.
American Coil Spring Co., 2034 Keating Ave., Muskegon, Mich.
American Spiral Spring & Mfg. Co., 5528 Harrison St., Pittsburgh, Pa.
American Spring & Wire Specialty Co., 816 N. Spaulding St., Chicago, Ill.
American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Art Wire & Stamping Co., 227 High St., Newark 2, N. J.
Barnes Co., Wallace, Div. of Associated Spring Corp., Bristol, Conn.
Barnes-Gibson-Raymond Div. of Associated Spring Corp., 6400 Miller Ave., Detroit 11, Mich.
Chatillon & Sons, John, 85-93 Cliff St., New York 7, N. Y.
Cleveland Wire Spring Co., 1281 East 38th Street, Cleveland, Ohio
Cuyahoga Spring Co., 10272 Berea Rd., Cleveland, Ohio
Dunbar Bros. Co., Div. of Associated Spring Corp., 76 South St., Bristol, Conn.
Garrett Co., Inc., George K., 1421 Chestnut St., Philadelphia 2, Pa.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Gibson Co., Wm. D., Div. of Associated Spring Corp., 1800 Clybourn Ave., Chicago, Ill.
Hubbard Spring Co., M. D., Central Ave., Pontiac, Mich.
Hunter Pressed Steel Co., Lansdale, Pa.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Instrument Specialties Co., 246 Bergen Blvd., Little Falls, N. J.
Jones Spring Co., W. B., 124 E. Seventh St., Cincinnati, Ohio
Lee Spring Co., 30 Main St., Brooklyn, N. Y.
Lizen Mfg. Co., 6832 S. Chicago Ave., Chicago 37, Ill.
Manross & Son, F. N. Div. of Associated Spring Corp., Bristol, Conn.
Mid-West Spring Mfg. Co., 4632 S. Western Ave., Chicago 9, Ill.
Muelhausen Spring Corp., 255 Michigan Ave., Logansport, Ind.
Newcomb Spring Corp., 238 40th St., Brooklyn 32, N. Y.
Peck Spring Co., Plainville, Conn.
Precision Products Co., 26 Bedford St., Waltham, Mass.
Raymond Mfg. Co., Div. of Associated Spring Corp., 226 S. Center St., Corry, Pa.
Reliable Spring & Wire Forms Co., 3167 Fulton Rd., Cleveland 9, Ohio
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Tuck Mfg. Co., 74 Ames, Brockton 46, Mass.
Union Spring & Mfg. Co., New Kensington, Pa.
Wickwire Spencer Steel Co., 500 Fifth Ave., New York, N. Y.

Stabilizers

VOLTAGE STABILIZERS

see Regulators

Stampings

METAL STAMPINGS, Small

Ace Manufacturing Corp., 1255 East Erie Ave., Philadelphia, Pa.
Allegheny Ludlum Steel Corp., Brackenridge, Pa.
American Brass Co., Waterbury 88, Conn.
American Emblem Co., Utica, N. Y.
American Nut & Bolt Fastener Co., 2045 Doerr St., Pittsburgh, Pa.
American Radio Hardware Co., Inc., 152 MacQuesten Pkway South, Mt. Vernon, N. Y.
American Spring & Wire Specialty Co., 816 N. Spaulding St., Chicago, Ill.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Art Wire & Stamping Co., 227 High St., Newark 2, N. J.
Atlas Tool & Design Co., Castor & Kensington Aves., Philadelphia 24, Pa.
Banks Mfg. Co., 1105 W. Lawrence Ave., Chicago 40, Ill.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Barnes-Gibson-Raymond Div. of Associated Spring Corp., 6400 Miller Ave., Detroit 11, Mich.
Belmont Smelting & Refining Works, Inc., 330 Belmont Ave., Brooklyn 7, N. Y.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Cole Steel Equipment, 349 Broadway, New York 13, N. Y.
Corry-Jamestown Manufacturing Corp., Corry, Pa.

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Croname, Inc., 3701 Ravenswood Ave., Chicago, Ill.
Dahlstrom Metallic Door Co., Buffalo St., Jamestown, N. Y.
Dayton Rogers Mfg. Co., 2835 12th Ave., South, Minneapolis 7, Minn.
Diamond Tool Replacements Div., Oscap Mfg. Co., Baltimore 1, Md.
Diebel Die & Mfg. Co., 3654 N. Lincoln Ave., Chicago, Ill.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Electric Auto-Lite Co., Toledo 1, Ohio
Electronic Supply Co., 207 Main St., Worcester, Mass.
Engineering Co., 27 Wright St., Newark, N. J.
Erie Art Metal Co., 1602 East 18th St., Erie, Pa.
Erie Can Co., 816 W. Erie St., Chicago 22, Ill.
Franklin Mfg. Corp., A. W., 175 Varick St., New York, N. Y.
Garrett Co., Inc., George K., 1421 Chestnut St., Philadelphia 2, Pa.
Goat Metal Stampings, Inc., 314 Dean St., Brooklyn, N. Y.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Grammes & Sons, L. F., 389 Union St., Allentown 2, Pa.
Heyman Mfg. Co., Kenilworth, N. J.
Hubbard Spring Co., M. D., 573 Central Ave., Pontiac, Mich.
Hunter Pressed Steel Co., Lansdale, Pa.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
King Laboratories, Inc., 205 Oneida St., Syracuse 4, N. Y.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Lewyt Corp., 60 Broadway, Brooklyn, N. Y.
Lizen Mfg. Co., 6832 S. Chicago Ave., Chicago 37, Ill.
Manufacturers Screw Products Co., 270 W. Hubbard St., Chicago, Ill.
Master Industries, Inc., 2415 Prairie Ave., Chicago 16, Ill.
Metallic Arts Co., 243 Broadway, Cambridge, Mass.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
New England Etching & Plating Co., 25 Spring St., Holyoke, Mass.
Oiljack Mfg. Co., Inc., Montclair, N. J.
Olympic Tool & Mfg. Co., 37 Chambers St., New York 7, N. Y.
O'Neil-Irwin Mfg. Co., 316 Eighth Ave. S., Minneapolis 15, Minn.
Patton-MacGuyer Co., 17 Virginia Ave., Providence 5, R. I.
Penn Fibre & Specialty Co., 2030 E. Westmoreland St., Philadelphia 34, Pa.
Porter Metal Products, 121 Ingraham St., Bklyn 6, N. Y.
Precision Fabricators, Inc., 120 N. Fitzhugh St., Rochester, N. Y.
Premax Products Div., Chisholm-Ryder Co., Niagara Falls 2, N. Y.
Quadriga Mfg. Co., 213 W. Grand Ave., Chicago 11, Ill.
Radiad Service, 720 West Schubert Ave., Chicago 14, Ill.
Radio Corp. of America, Tube Div. RCA, Harrison, N. J.
Raymond Mfg. Co., Div. of Associated Spring Corp., 226 S. Center Street, Corry, Pa.
Revere Copper & Brass Inc., 230 Park Ave., New York 17, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Small Motors, Inc., 1322 Elston Ave., Chicago 22, Ill.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South, Pasadena, Calif.
Stamford Metal Specialty Co., 428 Broadway, New York 13, N. Y.
Standard Pressed Steel Co., Jenkintown, Pa.
Stanley Works, New Britain, Conn.
Stewart Stamping Corp., 630 Central Park Ave., Yonkers 4, N. Y.
Stimpson Co., Inc., Edwin B., 74 Franklin Ave., Brooklyn 5, N. Y.
Swedish Iron & Steel Corp., 17 Battery Place, New York, N. Y.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Thermador Electric Mfg. Co., 5119 S. Riverside Dr., Los Angeles, Calif.
Thomas & Skinner Steel Prod. Co., 1120 E. 23rd St., Indianapolis, Ind.
Tricon Manufacturing Co., 8318 S. Racine Ave., Chicago, Ill.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
Union Aircraft Products Corp., 380 Second Ave., New York, N. Y.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Waters Conley Co., 501 First St., N.W., Rochester, Minn.
Webster-Chicago Corp., Manufacturing Div., 5622 Bloomingdale Ave., Chicago 39, Ill.
Western Brass Mills, Div. of Olin Industries, East Alton, Ill.
Whitehead Stamping Co., 1691 W. Lafayette Blvd., Detroit 16, Mich.
Willor Mfg. Co., 794 East 140th St., New York 53, N. Y.
Worcester Pressed Steel Co., 100 Barber Ave., Worcester, Mass.
Wrought Washer Mfg. Co., 2100 S. Bay St., Milwaukee 7, Wisc.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio
Zell Co., 538 Broadway, New York 12, N. Y.
Zierick Mfg. Corp., 385 Gerard Ave., New York, N. Y.

NON-METALLIC STAMPINGS, Small

Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne 1, Ind.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Auburn Mfg. Co., 110 Stack St., Middletown, Conn.
Baer Co., N. S., 9 Montgomery St., Hillside, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Continental-Diamond Fibre Co., 16 Chapel St., Newark, Del.
Diamond Tool Replacements Div., Oscap Mfg. Co., 207 W. Saratoga St., Baltimore 1, Md.
Electric Auto-Lite Co., Toledo 1, Ohio
Electronic Supply Co., 207 Main St., Worcester, Mass.
Franklin Fibre-Lamitex Corp., Wilmington, Del.
Franklin Mfg., A. W., 175 Varick St., New York, N. Y.
Hopp Press, Inc., 460 West 34th St., New York, N. Y.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Insulating Fabricators, Inc., 12 East 12th St., New York 3, N. Y.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Kulka Electric Mfg. Co., Inc., 30 South St., Mt. Vernon, N. Y.
Mica Insulator Co., 200 Varick St., New York 14, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Munsell & Co., Eugene, 200 Varick St., New York, N. Y.
National Vulcanized Fibre Co., Maryland Ave., Wilmington, Del.
Panelyte Div., St. Regis Paper Co., 230 Park Ave., New York, N. Y.
Penn Fibre & Specialty Co., 2030 E. Westmoreland St., Philadelphia 34, Pa.
Plastic Fabricators Co., 440 Sansome St., San Francisco 11, Calif.
Premax Products Div., Chisholm-Ryder Co., Niagara Falls 2, N. Y.
Radiad Service, 720 West Schubert Ave., Chicago 14, Ill.
Richardson Co., Melrose Park, Ill.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rogers Paper Mfg. Co., Manchester, Conn.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South Pasadena, Calif.
Spaulding Fibre Co., Inc., 310 Wheeler St., Tonawanda, N. Y.
Stamford Metal Specialty Co., 428 Broadway, New York 13, N. Y.
Synthane Corp., Oaks, Pa.
Tatlor Fibre Co., Norristown, Pa.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Westinghouse Elec. Corp., La... Bloomfield, N. J.
Westinghouse Electric Corp., E... burgh, Pa.
Willor Mfg. Co., 794 East 140t... York 54, N. Y.
Zierick Mfg. Corp., 385 Gerard ... York, N. Y.

Standards

CAPACITANCE STANDA...

Cornell-Dubilier Electric Corp., ...ilton Blvd., South Plainfield
Eastern Electronics Corp., 41 C... New Haven, Conn.
General Radio Co., 275 Mas... Ave., Cambridge 39, Mass.
Goodall Electric Mfg. Co., 320 ... St., Ogallala, Nebr.
Hewlett-Packard Co., 395 Page ... Palo Alto, Calif.
Industrial Instruments, Inc., ... Ave., Jersey City 5, N. J.
Leeds & Northrup Co., 4970 Ste... Philadelphia 44, Pa.
Richardson-Allen Corp., 15 Wes... New York 11, N. Y.
Standard Instruments Corp., 5... Ave., New York 55, N. Y.
White Research, 899 Boylston St... Mass.
Winslow Co., 9 Liberty St., ... N. J.
Winters & Crampton Corp., 1... Ave., Grandville, Michigan

FREQUENCY STANDARD...

Aero Communications, Inc., ... St., Hempstead, Long Island
Aireon Manufacturing Corp., ... Funston Rds., Kansas City
American Time Products, Inc., ... Ave., New York 19, N. Y.
Barker & Williamson, 255 Fairfi... Upper Darby, Pa.
Browning Labs., Inc., 750 Main ... chester, Mass.
Burnett Radio Lab., Wm. W., ... Idaho St., San Diego, Calif.
Conn, Ltd., C. G., Elkhart, Ind.
Crystal Research Labs, Inc., 29 A... Hartford, Conn.
Eastern Electronics Corp., 41 C... St., New Haven, Conn.
Eidson's, 1309 N. Second St., ... Texas
Electro Products Labs., 549 W. R... St., Chicago, Ill.
Erco Radio Labs., Inc., Fenimore ... Hempstead, N. Y.
Espey Mfg. Co., Inc., 33 West 4... New York 19, N. Y.
Ferris Instrument Co., 110-112 C... St., Boonton, N. J.
Gaertner Scientific Corp., 1201 W... wood Ave., Chicago, Ill.
General Communication Co., 530 Co... wealth Ave., Boston 15, Mass.
General Crystal Corp., 1775 Foster ... Schenectady, N. Y.
General Electric Co., Schenectady 5...
General Radio Co., 275 Massach... Ave., Cambridge 39, Mass.
Gibbs & Co., Thomas B., Divisio... George W. Borg Corp., 814 Mic... St., Delavan, Wisc.
Goodall Electric Mfg. Co., 320 N. S... St., Ogallala, Nebr.
Hallicrafters Co., 2611 Indiana Ave., ... cago 16, Ill.
Hearing Aid Labs., 1404 Franklin ... Michigan City, Ind.
Herbach & Rademan Co., Mfg. Div., ... Ludlow St., Philadelphia 5, Pa.
Hewlett-Packard Co., 395 Page Mill ... Palo Alto, Calif.
Higgins Industries, Inc., 2221 War... Ave., Santa Monica, Calif.
Jefferson, Inc., Ray, 40 E. Merrick ... Freeport, L. I., N. Y.
Knights Co., James, 131 S. Wells ... Sandwich, Ill.
Lavoie Laboratories, Morganville, N. J.
Leeds & Northrup Co., 4970 Stenton ... Philadelphia 44, Pa.
Leuck Crystal Laboratory, 245 S. 11th ... Lincoln 8, Nebr.
Meissner Mfg. Div., Maguire Indust... Inc., Mt. Carmel, Ill.
Megard Corp., 1601 S. Burlington St., ... Angeles 6, Calif.
Millen Mfg. Co., James, 150 Exchange ... Malden, Mass.
Pacific Electronics, Sprague at Jeffers... St., Spokane, Wash.

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ELECTRONIC and ALLIED PRODUCTS

Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rieber, Inc., Frank, 11916 W. Pico Blvd., Los Angeles 34, Calif.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Standard Instruments Corp., 568 Prospect Ave., New York 55, N. Y.
White Research, 899 Boylston St., Boston, Mass.

INDUCTANCE STANDARDS

Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
General Radio Co., 275 Massachusestts Ave., Cambridge 39, Mass.
Hewlett-Packard Co., 395 Page Mill Rd., Palo Alto, Calif.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Standard Instruments Corp., 568 Prospect Ave., New York 55, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
White Research, 899 Boylston St., Boston, Mass.

RESISTANCE STANDARDS

Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Industrial Instruments, Inc., 156 Culver Ave., Jersey City 5, N. J.
Instrument Resistors Co., 25 Amity St., Little Falls, N. J.
International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
White Research, 899 Boylston St., Boston, Mass.

Stands

MICROPHONE STANDS

American Microphone Co., 1915 S. Western Ave., Los Angeles, Cal.
Amperite Co., 561 Broadway, New York, N. Y.
Art Specialty Co., 3245 Lake St., Chicago, Ill.
Astatic Corp., Conneaut, Ohio
Atlas Sound Corp., 1443 39th St., Brooklyn, N. Y.
Bell Sound Systems, Inc., 1183 Essex Ave., Columbus, Ohio
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Eastern Mike-Stand Co., 56 Christopher Ave., Brooklyn 12, N. Y.
Electro Voice Corp., South Bend 24, Ind.
Electronic Sound Engineering Co., 109 N. Dearborn St., Chicago 2, Ill.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
Lifetime Sound Equipment Co., 1101 Adams St., Toledo, Ohio
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Newcomb Audio Products Co., 2815 S. Hill St., Los Angeles 18, Cal.
Oleson Illuminating Co., Ltd., Otto, 1560 Vine St., Hollywood 28, Calif.
Racon Electric Co., Inc., 52 East 19th St., New York 3, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radolek Co., 601 W. Randolph St., Chicago 6, Ill.
Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.
Shure Brothers, 225 W. Huron St., Chicago, Ill.
Simpson Mfg. Co., Mark, 188 W. Fourth St., New York, N. Y.
Turner Co., Cedar Rapids, Iowa
Universal Microphone Co., 424 Warren Lane, Inglewood, Cal.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.

SPEAKER STANDS

Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Art Specialty Co., 3245 Lake St., Chicago, Ill.
Atlas Sound Corp., 1443 39th St., Brooklyn, N. Y.
Electronic Sound Engineering Co., 109 N. Dearborn St., Chicago 2, Ill.
Erwood Co., 223 W. Erie St., Chicago, Ill.
Lifetime Sound Equipment Co., 1101 Adams St., Toledo, Ohio
Racon Electric Co., Inc., 52 E. 19th St., New York 3, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Simpson Mfg. Co., Inc., 188 W. Fourth St., New York, N. Y.
Vac-O-Grip Co., 2025 Detroit Ave., Toledo 6, Ohio

Steel

ELECTRICAL STEEL

see Metals

Strain Gauges

see Gauges, Strain

Strips

TERMINAL STRIPS

see Posts

Stroboscopes

Aerolux Light Corp., 653 11th Ave., New York 19, N. Y.
American Time Products, Inc., 580 Fifth Ave., New York 19, N. Y.
Communication Measurements Lab., 120 Greenwich St., New York, N. Y.
Conn, Ltd., C. G., Elkhart, Ind.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
J. F. D. Mfg. Co., 4111 Fort Hamilton Parkway, Brooklyn, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Saxl Instrument Co., 38-40 James St., East Providence 14, R. I.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.

Switches

LIMIT SWITCHES

Acro Electric Co., 1305 Superior Ave., Cleveland, Ohio
Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wis.
Allied Control Co., Inc., 2 East End Ave., New York 10, N. Y.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Atlas Products Corp., 30 Rockefeller Plaza, New York 20, N. Y.
Burling Instrument Co., 253 Springfield Ave., Newark, N. J.
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Electronic Control Corp., 1573 E. Forest St., Detroit, Mich.
General Electric Co., Schenectady 5, N. Y.
Hetherington & Son, Inc., Robert, Sharon Hill, Pa.
Master Electric Co., 126 Davis Ave., Dayton, Ohio
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Micro Switch Div. of First Industrial Corp., 7 Spring St., Freeport, Ill.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
Monitor Controller Co., 51 S. Gay St., Baltimore 2, Md.
Mu-Switch Corp., Canton 31, Mass.
Photoswitch, Inc 77 Broadway, Cambridge 42, Mass.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Titan Valve & Mfg. Co., 9913 Elk Ave., Cleveland, Ohio
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Ward Leonard Electric Co., 31 South St., Mt. Vernon, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.

MERCURY SWITCHES

Adams & Westlake Co., Michigan St., Elkhart, Ind.
Aerolux Light Corp., 653-11th Ave., New York 19, N. Y.
Arrow-Hart & Hegeman Electric Co., 103 Hawthorne St., Hartford, Conn.
Bacon Electric Timer Corp., 4513 Brooklyn Ave., Cleveland 9, Ohio
Brown Instrument Co., 4428 Wayne Ave., Philadelphia 44, Pa.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Durakool, Inc., 1010 N. Main St., Elkhart, Ind.
Electric Switch Corp., 14th at Union St., Columbus, Ind.
General Electric Co., Bridgeport, Conn.
H-B Electric Co., 6109 North 21st St., Philadelphia 38, Pa.
Littelfuse, Inc., 4755 Ravenswood Ave., Chicago, Ill.
Mercoid Corp., 4201 Belmont Ave., Chicago 41, Ill.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave., S., Minneapolis, Minn.
Pass & Seymour, Inc., Solvay Station, Syracuse, N. Y.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Westinghouse Electric Corp., East Pittsburgh, Pa.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

PRECISION SNAP ACTION SPRING

Acro Electric Co., 1305 Superior Avenue, Cleveland, Ohio
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Electrical Products Supply Co., 1140 Venice Blvd., Los Angeles 15, Calif.
General Control Co., 1200 Soldiers Field Rd., Boston 34, Mass.
General Electric Co., Schenectady 5, N. Y.
Grayhill Corp., 1 N. Pulaski Rd., Chicago, Ill.
Micro Switch Div. of First Industrial Corp., 7 Spring St., Freeport, Ill.
Mu-Switch Corp., 38 Pequit St., Canton 31, Mass.
Pass & Seymour, Inc., Solvay Station, Syracuse, N. Y.
Soreng Mfg. Corp., 1901 Clybourn Ave., Chicago 14, Ill.
Spencer Thermostat Co., 34 Forest St., Attleboro, Mass.
Standard Plastics, 1548 S. Robertson Blvd., Los Angeles 35, Calif.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.

ROTARY and BAND CHANGE SWITCHES

Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Autocall Co., 1142 Tucker Ave., Shelby, Ohio
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Bristol Co., Waterbury 91, Conn.

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Brown Instrument Co., 4428 Wayne Ave., Philadelphia 44, Pa.
Bryant Electric Co., Bridgeport 2, Conn.
Bud Radio, Inc., 2118 East 55 St., Cleveland 3, Ohio
Centralab Div., Globe Union, Inc., 900 E. Keefe Ave., Milwaukee 1, Wisc.
Cinema Engineering Co., 1508 W. Verdugo Ave., Burbank, Calif.
Clare & Co., C. P., 4719 Sunnyside Ave., Chicago 30, Ill.
Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn 1, N. Y.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Daven Co., 191 Central Ave., Newark 4, N. J.
Eastern Air Devices, Inc., 585 Dean St., Brooklyn 17, N. Y.
Electronic Mechanics, Inc., 70 Clifton Blvd., Clifton, N. J.
Franklin Mfg. Corp., A. W., 175 Varick St., New York, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Control Co., 1200 Soldiers Field Rd., Boston 34, Mass.
General Electric Co., Bridgeport, Conn.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Grayhill Corp., 1 N. Pulaski Rd., Chicago, Ill.
Hart Mfg. Co., 110 Bartholomew Ave., Hartford 1, Conn.
JBL Instrument Co., 420 E. Providence Rd., Aldan, Pa.
J-B-T Instruments, Inc., 441 Chapel St., New Haven 8, Conn.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Marion Electrical Instrument Co., Manchester, N. H.
Metallic Arts Co., 243 Broadway, Cambridge, Mass.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
Monitor Controller Co., 51 S. Gay St., Baltimore 2, Md.
Mossman, Inc., Donald P., 612 N. Michigan Ave., Chicago 11, Ill.
National Co., 61 Sherman St., Malden 48, Mass.
North Electric Mfg. Co., 501 S. Market St., Galion, Ohio
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago 44, Ill.
Peerless Labs, 461 Tenth Ave., New York 18, N. Y.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Roller-Smith, Bethlehem, Pa.
Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa.
Soreng Mfg. Corp., 1901 Clybourn Ave., Chicago 14, Ill.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Tech Laboratories, 7 Lincoln St., Jersey City, N. J.
Thwing-Albert Instrument Co., Penn St. & Pulaski Ave., Philadelphia 44, Pa.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Winslow Co., 31 Fulton St., Newark 2, N. J.
Wirt Co., 5221 Greene St., Philadelphia, Pa.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

TIME SWITCHES

American Time Products, Inc., 580 Fifth Ave., New York 19, N. Y.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Atlas Products Corp., 30 Rockefeller Plaza, New York 20, N. Y.
Automatic Electric Mfg. Co., 10 State St., Mankato, Minn.
Automatic Temperature Control Co., 34 E. Logan St., Philadelphia 44, Pa.
Bacon Electric Timer Corp., 4513 Brooklyn Ave., Cleveland 9, Ohio
Cleveland Time Clock & Service Co., Superior Ave. at E. 27th St., Cleveland, Ohio
Cutler-Hammer, Inc., 315 North 12th St., Milwaukee 1, Wisc.
Cramer Co., R. W., Centerbrook, Conn.
Eagle Signal Corp., Moline, Ill.
Edison, Inc., Thomas A., Instrument Div., 51 Lakeside Ave., West Orange, N. J.
General Control Co., 1200 Soldiers Field Rd., Boston 34, Mass.
General Electric Co., Schenectady 5, N. Y.
Haydon Manufacturing Co. Inc., Forestville, Conn.
Industrial Timer Corp., 117 Edison Pl., Newark 5, N. J.
Leach Relay Co., 5915 Avalon Blvd., Los Angeles, Calif.
Leich Electric Co., 565 W. Washington Blvd., Chicago 6, Ill.
Lektra Laboratories, Inc., 30 E. Tenth St., New York, N. Y.
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Mercoid Corp., 4201 Belmont Ave., Chicago, Ill.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave., S. Minneapolis, Minn.
Northwestern Clock Co., 514-15 Brown Bldg., Omaha, Neb.
Paragon Electric Co., 37 W. Van Buren St., Chicago 5, Ill.
Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.
Presto Electric Co., 4511 New York Ave., Union City, N. J.
Reliance Automatic Lighting Co., 1920 Mead St., Racine, Wis.
Reynolds Electric Co., 2650 W. Congress St., Chicago 12, Ill.
Rhodes, Inc., M. H., 30 Bartholomew Ave., Hartford, Conn.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Sangamo Electric Co., Springfield, Ill.
Schaar & Co., 754 W. Lexington St., Chicago 7, Ill.
States Co., 19 New Park Ave., Hartford 6, Conn.
Stoelting Co., C. H., 424 North Homan Ave., Chicago, Ill.
Techno-Scientific Co., 901 Nepperhan Ave., Yonkers 3, N. Y.
Thompson Clock Co., H. C., 38 Federal St., Bristol, Conn.
Tork Clock Co., 1 Grove St., Mount Vernon, N. Y.
Ulanet Co., George, 88 E. Kinney St., Newark 5, N. J. (thermal time delay)
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Wadsworth Electric Mfg. Co., Inc., 20 W. 11th St., Covington, Ky.
Walser Automatic Timer Co., 420 Lexington Ave., New York, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

TOGGLE and PUSHBUTTON SWITCHES

Acro Electric Co., 1305 Superior Ave., Cleveland, Ohio
Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Allis Chalmers Mfg. Co., Milwaukee 1, Wisc.
Arrow-Hart & Hegeman Electric Co., 103 Hawthorne St., Hartford, Conn.
Atlas Products Corp., 30 Rockefeller Plaza, New York 20, N. Y.
Aviometer Corp., 370 West 35th St., New York 1, N. Y.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Brown Instrument Co., 4428 Wayne Ave., Philadelphia 44, Pa.
Bryant Electric Co., Bridgeport 2, Conn.
Bud Radio, Inc., 2118 E. 55th St., Cleveland 3, Ohio
Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.
Centralab Div., of Globe Union, Inc., E. Keefe Ave., Milwaukee, Wis.
Clare & Co., C. P., 4719 Sunnyside Chicago 30, Ill.
Cole-Hersee Co., 54 Old Colony Ave. ton 27, Mass.
Connecticut Telephone & Electric Great American Industries, Brittania St., Meriden, Conn.
Cook Electric Co., 2700 Southport Chicago, Ill.
Cutler-Hammer Inc., 315 North 12th Milwaukee 1, Wisc.
Electronic Control Corp., 1573 E. St., Detroit, Mich.
Electronic Products Mfg. Co., 7360 River Drive, Dexter, Mich.
Federal Telephone and Radio Co. Broad St., Newark, N. J.
General Cement Mfg. Co., 919 Taylor Rockford, Ill.
General Control Co., 1200 Soldiers Rd., Boston 34, Mass.
General Electric Co., Bridgeport, Conn.
General Electric Co., Schenectady
Gits Molding Corp., 4600 Huron St. cago, Ill.
Grayhill Corp., 1 N. Pulaski Rd., Chicago Ill.
Hart Mfg. Co., 110 Bartholomew Hartford 1, Conn.
Hetherington & Son, Inc., Robert, Hill, Pa.
Hubbell, Inc., Harvey, Bridgeport
Insuline Corp. of America, 36-40 Ave., Long Island City, N. Y.
J. F. D. Mfg. Co., 4111 Fort Hill Parkway, Brooklyn, N. Y.
Kellogg Switchboard & Supply Co. S. Cicero Ave., Chicago 38, Ill.
Kulka Electric Mfg. Co., Inc., 30 St., Mt. Vernon, N. Y.
Leece-Neville Co., 5363 Hamilton Cleveland 14, Ohio
Mallory & Co., Inc., P. R., 3029 E. ington St., Indianapolis 6, Ind.
Metallic Arts Co., 243 Broadway, bridge, Mass.
Micro Switch Div. of First Ind. Corp., 7 Spring St., Freeport, Ill.
Minneapolis-Honeywell Regulator 2753 Fourth Ave., S. Minneapolis Minn.
Monitor Controller Co., 51 S. Gay Baltimore 2, Md.
Mossman, Inc., Donald P., 612 N. gan Ave., Chicago 11, Ill.
Mu-Switch Corp., Canton 31, Mass.
Muter Co., 1255 S. Michigan Ave., cago, Ill.
Oak Mfg. Co., 1260 Clybourn Ave., cago 10, Ill.
Pass & Seymour, Inc., Solvay St. Syracuse, N. Y.
Philmore Mfg. Co., 113 University P. New York, N. Y.
R.B.M. Mfg. Co., Div. of Essex Wire Logansport, Ind.
Remler Co., Ltd., 2101 Bryant St., Francisco 10, Calif.
Shure Brothers, 225 W. Huron St., cago, Ill.
Signal Engineering & Mfg. Co., 154 14th Street, New York, N. Y.
Soreng Mfg. Corp., 1901 Clybourn Chicago 14, Ill.
Stackpole Carbon Co., St. Marys, Pa.
Ucinite Co., 459 Watertown St., Newtonville, Mass.
United-Carr Fastener Corp., 31 Ames Cambridge 42, Mass.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Ward Leonard Electric Co., 31 South Mount Vernon, N. Y.
Warrick, Chas. F., 16251 Hamilton Detroit 3, Mich.
Westinghouse Electric Corp., East Pitt burgh, Pa.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

Tape

CELLULOSE and PLASTIC TAPE

Acadia Synthetic Products Div., Western Felt Works, 4035 Ogden Ave., Chicago 23, Ill.
American Phenolic Corp., 1830 S. 54th Ave., Chicago 50, Ill.
Bakelite Corp., 30 East 42nd St., New York 17, N. Y.
Dobeckmun Co., 3300 Monroe Ave., Cleveland, Ohio
Du Pont de Nemours & Co., Inc., E. I. Wilmington 98, Del.

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Extruded Plastics, Inc., Norwalk, Conn.
General Electric Co., Schenectady 5, N. Y.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Industrial Synthetics Corp., 60 Woolsey St., Irvington, N. J.
Industrial Tape Corp., New Brunswick, N. J.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Linton & Bro., Horace, 3081 Ruth St., Philadelphia, Pa.
Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
Minnesota Mining & Mfg. Co., 900 Fauquier Ave., St. Paul, Minn.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
National Varnished Products Corp., 211 Woodland Ave., Woodbridge, N. J.
Plax Corp., 133 Walnut St., Hartford 5, Conn.
Respro, Inc., Wellington Ave., Cranston, R. I.
Traver Corp., 358 W. Ontario St., Chicago 10, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wright & Sons Co., Wm. E., West Warren, Mass.

COTTON or SILK TAPE

Anchor Webbing Co., 1005 Main St., Pawtucket, R. I.
Carolina Narrow Fabric Co., 1036 N. Chestnut St., Winston-Salem, N. C.
Electro-Technical Products, Inc., Nutley 10, N. J.
Elizabeth Webbing Mills, Pawtucket, R. I.
General Electric Co., Bridgeport, Conn.
Goldmark Wire Co., James, 116 West St., New York 7, N. Y.
Hope Webbing Co., Providence, R. I.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Linton & Bro., Horace, 3081 Ruth St., Philadelphia, Pa.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
Priscilla Braid Co., 1461 High St., Central Falls, R. I.
Sidebotham, Inc., John, 4317 Griscom St., Philadelphia, Pa.
Sullivan & Sons Mfg. Co., J., 2224 N. Ninth St., Philadelphia 33, Pa.
Westinghouse Electric Corp., East Pittsburg, Pa.
Wright & Sons Co., Wm. E., West Warren, Mass.

VARNISHED TAPE

B.&C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Electro-Technical Products, Inc., Nutley 10, N. J.
Endurette Corp. of America, Cliffwood, N. J.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
Goldmark Wire Co., James, 116 West St., New York 7, N. Y.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Mitchell-Rand Insulation Co. Inc., 51 Murray St., New York 7, N. Y.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
New Jersey Wood Finishing Co., Inc., Electrical Insulation Dept., Woodbridge, N. J.
Standard Insulation Co., 74 Paterson Ave., East Rutherford, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.

TAPES, TELEGRAPH

Foote Pierson & Co., Inc., 75 Hudson St., Newark 4, N. J.
Paper Manufacturers Co., Philadelphia 18, Pa.

Television Mirrors

see Mirrors

Television Receivers

see Receivers

Television Transmitters

see Transmitters

Terminal Plugs

see Plugs

Terminal Strips

see Posts, Binding

Terminals and Lugs

see Lugs

Test Equipment for Tube Mfrs.

see Tube Manufacturers, Test Equip.

Testers

BATTERY TESTERS

Burton-Rogers Co., 857 Boylston St., Boston 16, Mass.
Chaslyn Co., 1952 Irving Park Rd., Chicago 13, Ill.
Eagle Electric Mfg. Co., Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Franklin Transformer, 65-22nd Ave. N. E., Minneapolis 13, Minn.
General Electric Co., Bridgeport, Conn.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
McColpin-Christie Corp., Ltd., 4922 S. Figueroa St., Los Angeles 37, Calif.
Philco Corp., Tioga & C Sts., Philadelphia, 34, Pa.
Precison Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, L. I., N. Y.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Radio Design Co., 1353 Sterling Place, Brooklyn, N. Y.
Sanborn Co., 39 Osborne St., Cambridge 39, Mass.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Sterling Mfg. Co., 9205 Detroit Ave., Cleveland, Ohio
Sun Mfg. Co., 6323 Avondale Ave., Chicago, Ill.
Supreme Instruments Corp., Greenwood, Miss.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Willard Storage Battery Co., 246 East 131st Street, Cleveland 1, Ohio
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

CAPACITOR TESTERS

Aerovox Corp., 740 Belleville Ave., New Bedford, Mass.
Clough-Brengle Co., 5501 N. Broadway, Chicago 22, Ill.
Communication Measurements Laboratory, 120 Greenwich St., New York, N. Y.
Connecticut Telephone & Electric Div. of Great American Industries, Inc., 70 Brittania St., Meriden, Conn.
Cornell-Dubilier Electric Corp., 1000 Hamilton Blvd., South Plainfield, N. J.
Deutschmann Corp., Tobe, Canton, Mass.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
Federal Instrument Co., 3931-47th Ave., Long Island City 4, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge, Mass.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Industrial Instruments, Inc., 156 Culver Ave., Jersey City 5, N. J.
Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 1, Ohio
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Music Master Mfg. Co., 542 S. Dearborn St., Chicago 5, Ill.
Philco Corp., Tioga & C Sts., Philadelphia, 34, Pa.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Design Co., 1353 Sterling Place, Brooklyn, N. Y.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Simpson Electric Co., 5218 W. Kinzie St., Chicago 44, Ill.
Solar Mfg. Corp., 285 Madison Ave., New York 17, N. Y.
Sprague Electric Co., North Adams, Mass.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

ELECTRICAL METER TESTERS

Acrolux Light Corp., 653-11th Ave., New York 19, N. Y.
Biddle Co., James G., 1213 Arch St., Philadelphia, Pa.
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Communication Measurements Laboratory, 120 Greenwich St., New York, N. Y.
Eagle Electric Mfg. Co., Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Eastern Specialty Co., 3619 N. Eighth St., Philadelphia 40, Pa.
Electronic Measurements Co., Red Bank, N. J.
General Electric Co., Schenectady 5, N. Y.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Marion Electrical Instrument Co., Manchester, N. H.
McFarlin Co., 29 W. Marion Ave., Youngstown, Ohio
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
States Co., 19 New Park Ave., Hartford 6, Conn.
Superior Instruments Co., 227 Fulton St., New York 7, N. Y.
Supreme Instruments Corp., Greenwood, Miss.
Westinghouse Electric Corp., East Pittsburg, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

INSULATION TESTERS

Acme Electric & Mfg. Co., 31 Water St., Cuba, New York
American Transformer Co., 178 Emmet St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Biddle Co., James G., 1213 Arch St., Philadelphia, Pa.
Communication Measurements Laboratory, 120 Greenwich St., New York, N. Y.
Electric Service Mfg. Co., 17th & Cambria Sts., Philadelphia 32, Pa.
Federal Instrument Co., 3931-47th Ave., Long Island City 4, N. Y.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
H-W Mfg. Co., 3124 Larga Ave., Los Angeles, Calif.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Holtzer Cabot, Signal Division, 400 Stuart St., Boston 17, Mass.
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.

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Industrial Instruments, Inc., 156 Culver Ave., Jersey City 5, N. J.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Leeds & Northrup Co., 4970 Stenton Ave., Philadelphia 44, Pa.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Miller Co., B. F., Trenton, N. J.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Frequency Laboratories, Inc., Boonton, N. J.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Rubicon Co., 3751 Ridge Ave., Philadelphia, Pa.
Springfield Sound Co., Electronics Division, 12 Cass St., Springfield, Mass.
Sticht Co., Inc., Herman H., 27 Park Place, New York 7, N. Y.
Superior Instruments Co., 227 Fulton St., New York 7, N. Y.
Tech Laboratories, 7 Lincoln St., Jersey City, N. J.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
U. S. Television Manufacturing Corp., 106 Seventh Ave., New York 11, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Winslow Co., 9 Liberty St., Newark 5, N. J.

SPRING TESTERS

Skyway Precision Tool Co., 3217 Casistas Ave., Los Angeles 26, Calif.

TUBE TESTERS

Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Clough-Brengle Co., 5501 N. Broadway, Chicago 22, Ill.
Dayco Radio Corp., 915 Valley St., Dayton 4, Ohio
Dayton Acme Co., 930 York St., Cincinnati, Ohio
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Grenby Mfg. Co., Plainville, Conn.
Hearing Aid Labs., 1404 Franklin St., Michigan City, Ind.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Jackson Electrical Instrument Co., 16-18 S. Patterson Blvd., Dayton 1, Ohio
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Philco Corp., Tioga & C Sts., Philadelphia 34, Pa.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Radio City Products Co., 127 W. 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radiotechnic Laboratory, 1328 Sherman Ave., Evanston, Ill.
Readrite Meter Works, College Ave., Bluffton, Ohio
Simpson Electric Co., 5218 W. Kinzie St., Chicago, Ill.
Standard Instruments Corp., 568 Prospect Ave., New York 55, N. Y.
Superior Instruments Co., 227 Fulton St., New York 7, N. Y.
Supreme Instruments Corp., Greenwood, Miss.
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Technical Devices Corp., Beaufort & Eagle Rock Aves., Roseland, N. J.
Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

VIBRATION TESTERS

All American Tool & Mfg. Co., 1014 W. Fullerton St., Chicago 14, Ill.
Commercial Research Labs., Inc., 20 Bartlett Ave., Detroit 3, Mich.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
L. A. B. Corp., Summit, N. J.
MB Manufacturing Co., 1060 State St., New Haven, Conn.
Offner Electronics, Inc., 5320 N. Kedzie Ave., Chicago 25, Ill.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Technical Products Co., 158 Madison Ave. at Third St., Memphis, Tenn.
Waugh Labs., Div. of Waugh Equipment Co., 420 Lexington Ave., New York 17, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Westinghouse Electric Corp., Industrial & X-Ray Divs., Baltimore 3, Md.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

VOLTAGE TESTERS

Aerolux Light Corp., 653 Eleventh Ave., New York 19, N. Y.
American Transformer Co., 178 Emmet St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Electrical Facilities, Inc., 4224 Holden St., Oakland 8, Calif.
Electro Products Laboratories, 549 West Randolph St., Chicago, Ill.
Electronic Measurements Co., Red Bank, N. J.
Espey Mfg. Co., Inc., 33 West 46th St., New York 19, N. Y.
General Electric Co., Schenectady 5, N. Y.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Ideal Commutator Dresser Co., 1291 Park Ave., Sycamore, Ill.
Industrial Instruments, Inc., 156 Culver Ave., Jersey City 5, N. J.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lepel High Frequency Laboratories, 39 West 60th Street, New York, N. Y.
Miller Co., B. F., Trenton, N. J.
Northern Laboratories, Ltd., 3-01 27th Ave., Long Island City, N. Y.
Precision Apparatus Co., 92-27 Horace Harding Blvd., Elmhurst, N. Y.
Radio City Products Co., 127 West 26th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., Waltham, Mass.
Roller-Smith, Bethlehem, Pa.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
States Co., 19 New Park Ave., Hartford 6, Conn.
Takk Corporation, Newark, Ohio
Technical Apparatus Co., 1171 Tremont St., Boston 20, Mass.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Thermocouple Meters

see Meters

Thermocouples

VACUUM THERMOCOUPLES

Aerolux Light Corp., 653-11th Ave., New York 19, N. Y.
American Thermo-Electric Co., 67 East 8th St., New York 3, N. Y.
Avia Products Co., 7266 Beverly Blvd., Los Angeles 36, Calif.
Cambridge Instrument Co., 3732 Grand Central Terminal, New York 17, N. Y.
Engelhard, Inc., Charles, 233 N. J. R. R. Ave., Newark, N. J.
Eppley Laboratory, Inc., Newport, R. I.
Fenwal, Inc., Ashland, Mass.
Field Electric Instrument Co., 109 East 184th St., New York 53, N. Y.
Fredericks Co., Geo. E., Bethayres, Pa.
General Electric Co., Schenectady 5, N. Y.
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio
Illinois Testing Laboratories, Inc., 420 N. LaSalle St., Chicago, Ill.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Calif.
National Research Corp., Vacuum Engrg. Div., Boston 15, Mass.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Sensitive Research Instrument Co., 9 Elm Ave., Mt. Vernon, N. Y.
Sundt Engineering Co., 4757 Ravenswood Ave., Chicago, Ill.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Universal X-Ray Products Inc., 1800 North Francisco Ave., Chicago 47, Ill.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wheelco Instruments Corp., 847 W. Harrison St., Chicago 7, Ill.
Winslow Co., 9 Liberty St., Newark 5, N. J.
Xervac Instrument Co., 101 Vine St., Hartford 5, Conn.

Timers

AUTOMATIC CYCLE TIMERS

American Time Products, Inc., 580 Fifth Ave., New York 19, N. Y.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Auth Electrical Specialty Co., Inc., 421 East 53rd St., New York 22, N. Y.
Automatic Temperature Control Co., 34 E. Logan St., Philadelphia 44, Pa.
Barber-Colman Co., Rockford, Ill.
Bristol Co., Waterbury 91, Conn.
Cole-Hersee Co., 54 Old Colony Ave., Boston 27, Mass.
Cramer Co., R. W., Centerbrook, Conn.
Cutler-Hammer, Inc., 315 North 12th Street Milwaukee 1, Wisc.
Cyclotron Specialties Co., Moraga, Calif.
Eagle Signal Corp., Moline, Ill.
Electric Switch Corp., 14th at Union St., Columbus, Ind.
Electronic Measurements Co., Red Bank, N. J.
Foxboro Co., Foxboro, Mass.
General Control Co., 1200 Soldiers Field Rd., Boston 34, Mass.
General Electric Co., Schenectady 5, N. Y.
Gorrell & Gorrell, 40 Littlefield Rd., Newton Centre, Mass.
Haydon Manufacturing Co., Inc., Forestville, Conn.
Holtzer-Cabot Signal Division, 400 Stuart St., Boston 17, Mass.
Industrial Timer Corp., 117 Edison Pl., Newark 5, N. J.
Luers, J. Milton, 12 Pine St., Mt. Clemens, Michigan
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
North Electric Mfg. Co., 501 S. Market St., Galion, Ohio
Paragon Electric Co., 37 W. Van Buren St., Chicago 5, Ill.
Philharmonic Radio Corp., 528 E. 72nd St., New York 21, N. Y.
Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.
Portable Products Corp., C. J. Tagliabue Div., 550 Park Ave., Brooklyn 5, N. Y.
Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, Long Island, N. Y.
Reynolds Electric Co., 2650 W. Congress St., Chicago 12, Ill.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Rowe Radio Research Laboratory Co., 2422 N. Pulaski Rd., Chicago 39, Ill.
Sangamo Electric Co., Springfield, Ill.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Stoelting Co., C. H., 424 N. Homan Ave., Chicago, Ill.
Stromberg Time Corp., 109 Lafayette St., New York, N. Y.
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Teleoptic Co., 1241 Mound Ave., Racine, Wisc.
Thompson Clock Co., H. C., 38 Federal St., Bristol, Conn.
Tork Clock Co., 1 Grove St., Mt. Vernon, N. Y.
Wallace & Tiernan Products, Inc., Belleville, N. J.

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ELECTRONIC and ALLIED PRODUCTS

Walser Automatic Timer Co., 420 Lexington Ave., New York, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

AUTOMATIC INTERVAL TIMERS

Allen-Bradley Co., 136 W. Greenfield Ave., Milwaukee 2, Wisc.
Allied Control Co., Inc., 2 East End Ave., New York 10, N. Y.
American Time Products, Inc., 580 Fifth Ave., New York 19, N. Y.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Automatic Electric Mfg. Co., 10 State St., Mankato, Minn.
Automatic Temperature Control Co., 34 E. Logan St., Philadelphia 44, Pa.
Bacon Electric Timer Corp., 4513 Brooklyn Ave., Cleveland 9, Ohio
Bristol Co., Waterbury 91, Conn.
Brush Development Co., 3405 Perkins Ave., Cleveland 14, Ohio
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Cyclotron Specialties Co., Moraga, Calif.
Cramer Co., R. W., Centerbrook, Conn.
Eagle Signal Corp., Moline, Ill.
Eastman Kodak Co., Rochester 4, N. Y.
Edison, Inc., Thomas A., Instrument Div., 51 Lakeside Ave., West Orange, N. J.
Electric Controller & Mfg. Co., 2694 East 79th St., Cleveland, Ohio
Electric Switch Corp., 14th at Union St., Columbus, Ind.
Electronic Control Corp., 1573 E. Forest St., Detroit, Mich.
Electronic Measurements Co., Red Bank, N. J.
Electronic Sound Engineering Co., 109 N. Dearborn St., Chicago 2, Ill.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Gaertner Scientific Corp., 1201 Wrightwood Ave., Chicago, Ill.
General Electric Co., Schenectady 5, N. Y.
General Electric X-Ray Corp., 2012 Jackson Blvd., Chicago, Ill.
Gilbert Clock Co., Wm. M., Winsted, Conn.
Gorrell & Gorrell, 40 Littlefield Rd., Newton Centre, Mass.
Guardian Electric Mfg. Co., 1400 Washington Blvd., Chicago 7, Ill.
Haydon Manufacturing Co., Inc., Forestville, Conn.
Holtzer-Cabot Signal Division, 400 Stuart St., Boston 17, Mass.
Industrial Engineering Corp., Rea Building, Terre Haute, Ind.
Industrial Timer Corp., 117 Edison Pl., Newark 5, N. J.
Lektra Laboratories, Inc., 30 E. Tenth St., New York, N. Y.
Luers, J. Milton, 12 Pine St., Mt. Clemens, Michigan
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Lux Clock Manufacturing Co., Waterbury, Conn.
Mallory & Co. Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Minneapolis-Honeywell Regulator Co., 2753 Fourth Ave. S., Minneapolis, Minn.
National Electric Mfg. Co., 103 E. Ferry St., Berrien Springs, Michigan
Northwestern Clock Co., 514-15 Brown Bldg., Omaha, Neb.
Paragon Electric Co., 37 W. Van Buren St., Chicago 5, Ill.
Philharmonic Radio Corp., 528 E. 72nd St., New York 21, N. Y.
Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y.
Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, Long Island, N. Y.
Rawson Electrical Instrument Co., Inc., 110 Potter St., Cambridge 42, Mass.
Reliance Automatic Lighting Co., 1920 Mead St., Racine, Wisc.
Reynolds Electric Co., 2650 W. Congress St., Chicago 12, Ill.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Rieber, Inc., Frank 11916 W. Pico Blvd., Los Angeles 34, Calif.
Rowe Radio Research Laboratory, 2422 N. Pulaski Rd., Chicago 29, Ill.
Sangamo Electric Co., Springfield, Ill.
Schaar & Co., 754 W. Lexington St., Chicago 7, Ill.
Seth Thomas Clock, Div. of General Time Instrument Corp., Thomaston, Conn.
Signal Engineering & Manufacturing Co., 154 W. 14th St., New Yerk, N. Y.
Sorenson & Co., 375 Fairfield Ave., Stamford, Conn.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Stoelting Co., C. H., 424 N. Homan Ave., Chicago, Ill.
Stromberg Time Corp., 109 Lafayette St., New York, N. Y.
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Technical Products Co., 158 Madison Ave., at Third St., Memphis, Tenn.
Teleoptic Co., 1241 Mound Ave., Racine, Wisc.
Thompson Clock Co., H. C., 38 Federal St., Bristol, Conn.
Tork Clock Co., 1 Grove St., Mt. Vernon, N. Y.
Union Switch & Signal Co., Swissvale, Pa.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Wallace & Tiernan Products, Inc., Belleville, N. J.
Walser Automatic Timer Co., 420 Lexington Ave., New York, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

AUTOMATIC RESET TIMERS

American Type Founders, 11 West 42nd St., New York, N. Y.
Ansonia Clock Co., Inc., 103 Lafayette St., New York 13, N. Y.
Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Automatic Electric Mfg. Co., 10 State St., Mankato, Minn.
Automatic Temperature Control Co., 34 E. Logan St., Philadelphia 44, Pa.
Bristol Co., Waterbury 91, Conn.
Cramer Co., R. W., Centerbrook, Conn.
Eagle Signal Corp., Moline, Ill.
General Control Co., 1200 Soldiers Field Rd., Boston 34, Mass.
Gorrell & Gorrell, 40 Littlefield Rd., Newton Centre, Mass.
Haydon Manufacturing Co., Inc., Forestville, Conn.
Holtzer-Cabot Signal Div., 400 Stuart St., Boston 17, Mass.
Industrial Timer Corp., 117 Edison Pl., Newark 5, N. J.
Luers, J. Milton, 12 Pine St., Mt. Clemens, Michigan
Lumenite Electric Co., 407 S. Dearborn St., Chicago, Ill.
Lux Clock Manufacturing Co., Waterbury, Conn.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
National Electric Mfg. Co., 103 E. Ferry St., Berrien Springs, Michigan
Paragon Electric Co., 37 W. Van Buren St., Chicago 5, Ill.
Partlow Corp., 2 Campion Rd., New Hartford, N. Y.
Photoswitch, Inc., 77 Broadway, Cambridge 42, Mass.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y.
Portable Products Corp., C. J., Tagliabue Div., 550 Park Ave., Brooklyn 5, N. Y.
Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, Long Island, N. Y.
Reliance Automatic Lighting Co., 1920 Mead St., Racine, Wisc.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Sangamo Electric Co., Springfield, Ill.
Schaar & Co., 754 W. Lexington St., Chicago 7, Ill.
Self Winding Clock Co., 205 Willoughby Avenue, Brooklyn 5, N. Y.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Stoelting Co. C. H., 424 North Homan Ave., Chicago, Ill.
Stromberg Time Corp., 109 Lafayette St., New York, N. Y.
Struthers-Dunn, Inc., 1321 Arch St., Philadelphia 7, Pa.
Technical Products Co., 158 Madison Ave., at Third St., Memphis, Tenn.
Teleoptic Co., 1241 Mound Ave., Racine, Wisc.
Tork Clock Co., 1 Grove St., Mt. Vernon, N. Y.
Ulanet Co., George, 88 E. Kinney St., Newark 5, N. J.
Westinghouse Electric Corp., East Pittsburg, Pa.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.
Zenith Electric Co., 152 W. Walton St., Chicago, Ill.

PHOTO-ELECTRIC TIMERS

Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Cramer Co., R. W., Centerbrook, Conn.
Electronic Measurements Co., Red Bank, N. J.
Electronic Products Co., 19 North First St., Geneva, Ill.
General Electric Co., Schenectady 5, N. Y.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
National Electric Mfg. Co., 103 E. Ferry St., Berrien Springs, Mich.
Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, Long Island, N. Y.
Richardson-Allen Corp., 15 W. 20th St., New York 11, N. Y.
Schaar & Co., 754 W. Lexington St., Chicago 7, Ill.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Standard Electric Time Co., 89 Logan St., Springfield, Mass.
Stoelting Co., C. H., 424 North Homan Ave., Chicago, Ill.
Technical Products Co., 158 Madison Ave., at Third St., Memphis, Tenn.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Worner Electronic Devices, 609 West Lake St., Chicago 6, Ill.

WELDING TIMERS

Clark Controller Co., 1146 East 152nd St., Cleveland, Ohio
Eisler Engineering Co., 740 S. 13th St., Newark 3, N. J.
Electric Controller & Mfg. Co., 2694 East 79th St., Cleveland, Ohio
Electronic Products Co., 19 N. First St., Geneva, Ill.
General Electric Co., Schenectady 5, N. Y.
Glenn-Roberts Co., 3100 E. Tenth St., Oakland 1, Calif.
Pier Equipment Mfg. Co., Benton Harbor, Mich.
Weltronic Co., 3080 E. Outer Drive, Detroit 17, Mich.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Tools

SCREWDRIVERS and SMALL INSULATED TOOLS

Atlas Tool & Designing Co., Castor & Kensington Aves., Philadelphia 24, Pa.
Bonney Forge & Tool Works, Allentown, Pa.
Bridgeport Hardware Mfg. Corp., Iranistan Ave., Bridgeport, Conn.
Burndy Engrg. Co., Inc., 107 Bruckner Blvd., New York 54, N. Y.
Detroit Power Screwdriver Co., 2801 W. Fort St., Detroit 16, Mich. (Magazine Feed Power Screwdriver)
Dumore Co., 14th & Racine Sts., Racine, Wisc.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Fairmount Tool & Forge Co., 10611 Quincy Ave., Cleveland, Ohio
General Cement Mfg. Co., 919 Taylor, Rockford, Ill.
Greenlee Tool Co., 2136 Twelfth St., Rockford, Ill.
Hy-Pro Tool Co., New Bedford, Mass.
Invincible Tool Co., 611 Empire Bldg., Pittsburgh 22, Pa.
Linick & Co., Leslie L., 29 E. Madison St., Chicago, Ill.
O'Neil-Irwin Mfg. Co., 316 Eighth Ave. S., Minneapolis 15, Minn.
Park Metalware Co., 28 Bank St., Orchard Park, N. Y.
Richmont, Inc., 215 W. Seventh St., Los Angeles 14, Calif.
Scherr, George D., 128 Lafayette St., New York, N. Y.
Speedway Mfg. Co., 1834 South 52nd Ave., Cicero 50, Ill.
Stanley Works, New Britain, Conn.

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Stedman, Robert L., Oyster Bay, New York.
Stevens Walden, Inc., 459 Schrewsbury St., Worcester, Mass.
Tuck Mfg. Co., 74 Ames St., Brockton 64, Mass.
Utica Drop Forge & Tool Corp., 2415 Whitesboro St., Utica 4, N. Y.
Vaco Products Co., 317 E. Ontario St., Chicago 11, Ill.
Webster Chicago Corp., Manufacturing Div., 5622 Bloomingdale Ave., Chicago 39, Ill.
Willor Mfg. Co., 794 East 140th St., New York 54, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

Transceivers

ARF Products Co., 7627 W. Lake St., River Forest, Ill.
Alreon Mfg. Corp., Kansas City 15, Kans.
Bendix Radio Corp., Baltimore 4, Md.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
General Electric Co., Bridgeport, Conn.
Hallicrafters Co., 2611 S. Indiana Ave., Chicago 16, Ill.
Herbach & Rademan Co., 517 Ludlow St., Philadelphia 6, Pa.
Hoffman Radio Corp., 3430 S. Hill St., Los Angeles, Calif.
Lear, Inc., Piqua, Ohio
Meck Industries, John, Liberty at Pennsylvania, Plymouth, Ind.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Megard Corp., 1601 S. Burlington Ave., Los Angeles 6, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Receptor Co., Inc., 251 West 19th St., New York, N. Y.
Raytheon Mfg. Co., 60 East 42nd St., New York, N. Y.
Remler Co., Ltd., 2101 Bryant St., San Francisco, Calif.
Searle Aero Industries, Inc., Orange, Calif.
Tech-Master Products Co., 123 Prince St., New York, N. Y.
United States Television Mfg. Corp., 106 Seventh Ave., New York, N. Y.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.

Transformers

AUDIO & POWER TRANSFORMERS

Acme Electric & Mfg. Co., 31 Water St., Cuba, N. Y.
Advance Transformer Co., 14 N. May St., Chicago, Ill.
Airdesign & Fabrication, Inc., 241 Fairfield Ave., Upper Darby, Pa.
Allis Chalmers Mfg. Co., Milwaukee 1, Wisc.
Altec Lansing Corp., 1680 N. Vine St., Los Angeles 28, Calif.
American Television & Radio Co., 300 East Fourth Street, St. Paul 1, Minn.
American Transformer Co., 178 Emmett St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Audio Development Co., 2833 13th Ave., S., Minneapolis 7, Minn.
Automatic Mfg. Co., 900 Passaic Ave., E. Newark, N. J.
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago, Ill.
Best Mfg. Co., Inc., 1200 Grove St., Irvington 1, N. J.
Chicago Transformer Div., Essex Wire Corp., 3501 W. Addison St., Chicago 18, Ill.
Cinaudagraph Speakers, Inc., 3911 S. Michigan Ave., Chicago, Ill.
Consolidated Radio Products Co., 350 W. Erie St., Chicago 10, Ill.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
Davis & Co., Inc., Dean W., Kentland, Ind.
Dinion Coil Co., Inc., 1 North St., Caledonia, N. Y.
Dongan Electric Mfg. Co., 2987 Franklin St., Detroit, Mich.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electrical Specialty Co., 2304 Washington St., Boston, Mass.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Components, 423 N. Western Ave., Los Angeles 4, Calif.
Electronic Engineering Co., 3223 West Armitage Ave., Chicago, Ill.
Electronic Transformer Co., 207 W. 25th St., New York, N. Y.
Erie Electric Co., 120 Church St., Buffalo, N. Y.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Foster Co., A. P., 719 Wyoming Ave., Lockland 15, Ohio
France Mfg. Co., 10325 Berea Rd., Cleveland, Ohio
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
Gardner Electric Mfg. Co., 4227 Hollis St., Emeryville 8, Calif.
General Electric Co., Schenectady 5, N. Y.
General Transformer Corp., 1250 W. Van Buren St., Chicago 7, Ill.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Gramer Co., 2734 N. Pulaski Rd., Chicago 39, Ill.
Guided Radio Corp., 161 Sixth Ave., New York 13, N. Y.
Hadley Co., Robert M., 711 E. 61st St., Los Angeles, Calif.
Halldorson Company, The, 4500 Ravenswood Ave., Chicago 28, Ill.
Heinze Electric Co., Lowell, Mass.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
Hollywood Transformer Co., 645 N. Martel Ave., Los Angeles 36, Calif.
Hudson American Corp., 25 W. 43rd St., New York, N. Y.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
International Transformer Co., 396 Broadway, New York, N. Y.
Jefferson Electric Co., Bellwood, Ill.
Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago, Ill.
Kegron Mfg. Co., Inc., 18 West 20th St., New York 11, N. Y.
Kenyon Transformer Co., 840 Barry St., New York 59, N. Y.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Kyle Corp., South Milwaukee, Wisc.
Langevin Co., Inc., 37 West 65th St., New York, N. Y.
Magnavox Co., The, 2131 Bueter Road, Fort Wayne 4, Ind.
Magnetic Windings Co., Div. of Essex Wire Corp., 416 South 16th St., Easton, Pa.
Merit Coil & Transformer Corp., 4427 N. Clark St., Chicago 40, Ill.
Moloney Electric Co., 5390 Bircher Blvd., St. Louis 20, Mo.
National Co., 61 Sherman St., Malden 48, Mass.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Newark Transformer Co., 17 Frelinghuysen Ave., Newark, N. J.
Newcomb Audio Products Co., 2815 S. Hill St., Los Angeles 18, Calif.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles 1, Calif.
Peerless Laboratories, 461 Tenth Ave., New York 18, N. Y.
Permoflux Corp., 4900 W. Grand Ave., Chicago, Ill.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Precision Transformer Co., 733 West Ohio St., Chicago 10, Ill.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radionic Controls Inc., 3758 Belmont Ave., Chicago 18, Ill.
Radionic Transformer Co., 411 S. Sangamon St., Chicago, Ill.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Red Arrow Electric Corp., 100 Colt St., Irvington, N. J.
Rola Co., Inc., 2530 Superior Ave., Cleveland, Ohio
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South Pasadena, Calif.
Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.
Sonotone Corp., P. O. Box 200, Saw Mill River Road, Elmsford, N. Y.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Standard Electrical Products Co., 400 Linden Ave., Dayton 3, Ohio
Standard Transformer Corp., 1500 N. Halsted St., Chicago, Ill.
States Co., 19 New Park Ave., Hartford 6, Conn.
Stockwell Transformer Corp., 569 S. Main St., Akron, Ohio
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Superior Electric Co., 83 Laurel St., Bristol, Conn.
Swain Nelson Co., 2320 Glenview Rd., Glenview, Ill.
Telex Products Co., Telex Park, Minneapolis 1, Minn.
Thermador Electric Mfg. Co., 5119 S. Riverside Drive, Los Angeles 22, Calif.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
Transformer Products, Inc., 143 W. 51st St., New York, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Uptegraff Mfg. Co., R. E., Scottdale, Pa.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Walsh Engineering Co., 34 DeHart Place, Elizabeth, N. J.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Whisk Laboratories, 87 Maiden Lane, New York 7, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

CURRENT TRANSFORMERS

Advance Transformer Co., 14 N. May St., Chicago, Ill.
Airdesign & Fabrication, Inc., 241 Fairfield Ave., Upper Darby, Pa.
Allis Chalmers Mfg. Co., Milwaukee 1, Wis.
American Television & Radio Co., 300 East Fourth St., St. Paul 1, Minn.
American Transformer Co., 178 Emmett St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Annis Co., R. B., 1101 N. Delaware St., Indianapolis 2, Ind.
Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Burlington Instrument Corp., 214 North 4th St., Burlington, Iowa
Chicago Transformer Div., Essex Wire Corp., 3501 W. Addison St., Chicago 18, Ill.
Cinaudagraph Speakers, Inc., 3911 S. Michigan Ave., Chicago, Ill.
Davis & Co., Dean W., Kentland, Ind.
Dinion Coil Co., Inc., North St., Caledonia, N. Y.
Eastern Specialty Co., 3619 N. Eighth St., Philadelphia 40, Pa.
Eisler Engineering Co., 740 South 13th St., Newark 3, N. J.
Electrical Facilities, Inc., 4224 Holden St., Oakland 8, Calif.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Engineering Co., 3223 West Armitage Ave., Chicago, Ill.
Electronic Transformer Co., 207 W. 25th St., New York, N. Y.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Esterline Angus Co., Inc., P. O. Box 596, Indianapolis, Ind.
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
General Controls Co., 801 Allen Ave., Glendale, Calif.

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ELECTRONIC and ALLIED PRODUCTS

General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
General Transformer Corp., 1250 W. Van Buren St., Chicago 7, Ill.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Hadley Co., Robert M., 711 East 61st St., Los Angeles, Calif.
Halldorson Company, 4500 Ravenswood Ave., Chicago 28, Ill.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Jefferson Electric Co., Bellwood, Ill.
Johnson, E. F., Co., Waseca, Minn.
Kyle Corp., South Milwaukee, Wis.
Langevin Co., Inc., 37 West 65th St., New York, N. Y.
Merit Coil & Transformer Corp., 4427 N. Clark St., Chicago 40, Ill.
Moloney Electric Co., 5390 Bircher Blvd., St. Louis 20, Mo.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Newark Transformer Co., 17 Frelinghuysen Ave., Newark, N. J.
Niagara Electric Improvement Corp., 51 East 42nd St., New York, N. Y.
Northelfer Winding Labs., 111 Albermarle Ave., Trenton, N. J.
Peerless Laboratories, 461 Tenth Ave., New York 18, N. Y.
Presto Electric Corp., 4511 New York Ave., Union City, N. J.
Radionic Transformer Co., 411 S. Sangamon St., Chicago, Ill.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Red Arrow Electric Corp., 100 Colt St., Irvington, N. J.
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J.
Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Superior Electric Co., 83 Laurel St., Bristol, Conn.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
Transformer Products, Inc., 143 W. 51st St., New York, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Uptegraff Mfg. Co., R. E., Scottdale, Pa.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Walsh Engineering Co., 34 Dehart Place, Elizabeth, N. J.
Welch Scientific Co., W. M., 1515 Sedgwick St., Chicago 10, Ill.
Western Electro-Mechanical Co., 300 Broadway, Oakland, Calif.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Whisk Laboratories, 87 Maiden Lane, New York 7, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

INSTRUMENT TRANSFORMERS

Allis Chalmers Mfg. Co., Milwaukee 1, Wis.
American Transformer Co., 178 Emmett St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Annis Co., R. B., 1101 N. Delaware St., Indianapolis 2, Ind.
Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.
Automatic Mfg. Co., 900 Passaic Ave., E. Newark, N. J.
Best Mfg. Co., Inc., 1200 Grove St., Irvington 1, N. J.
Boes Co., W. W., 3001 Salem Ave., Dayton 3, Ohio
Burlington Instrument Corp., 214 North 4th St., Burlington, Ia.
Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass.
Chicago Transformer Div., Essex Wire Corp., 3501 W. Addison St., Chicago 18, Ill.
Davis & Co., Inc., Dean W., Kentland, Ind.
Dinion Coil Co. Inc., 1 North St., Caledonia, N. Y.
Eastern Specialty Co., 3617-19 N. Eighth St., Philadelphia 40, Pa.
Eisler Engineering Co., 740 South 13th St., Newark 3, N. J.
Electrical Facilities, Inc., 4224 Holden St., Oakland 8, Calif.
Electronic Engineering Co., 3223 West Armitage Ave., Chicago, Ill.
Electronic Transformer Co., 207 West 25th St., New York, N. Y.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Erie Electric Co., 120 Church St., Buffalo, N. Y.
Esterline-Angus Co., Inc., P. O. Box 596, Indianapolis, Ind.
Ferranti Electric Inc., 30 Rockefeller Plaza, New York 20, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
General Transformer Corp., 1250 W. Van Buren St., Chicago 7, Ill.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio
Hollywood Transformer Co., 645 N. Martel Ave., Los Angeles 36, Calif.
International Transformer Co., 396 Broadway, New York, N. Y.
Johnson Co., E. F., Waseca, Minn.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Magnetic Windings Co., Div. of Essex Wire Corp., 416 South 16th St., Easton, Pa.
Merit Coil & Transformer Corp., 4427 N. Clark St., Chicago 40, Ill.
National Co., 61 Sherman St., Malden 48, Mass.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Newark Transformer Co., 17 Frelinghuysen Ave., Newark, N. J.
Niagara Electric Improvement Corp., 51 East 42nd St., New York, N. Y.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Presto Electric Co., 4511 New York Ave., Union City, N. J.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radionic Transformer Co., 411 S. Sangamon St., Chicago, Ill.
Red Arrow Electric Corp., 100 Colt St., Irvington, N. J.
Roller-Smith, Bethlehem, Pa.
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J.
Sparkes Mfg. Co., 318 Jefferson St., Newark, N. J.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Uptegraff Mfg. Co., R. E., Scottdale, Pa.
Walsh Engineering Co., 34 De Hart Place, Elizabeth, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Whisk Laboratories, 87 Maiden Lane, New York 7, N. Y.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

RF AND IF TRANSFORMERS

Aladdin Radio Industries, Inc., 501 W. 35th St., Chicago 16, Ill.
Automatic Mfg. Co., 900 Passaic Ave., East Passaic, N. J.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Best Mfg. Co., Inc., 1200 Grove St., Irvington 1, N. J.
Bridgeport Mfg. Co., Bridgeport, Ill.
Cambridge Thermionic Corp., 445 Concord Ave., Cambridge, Mass.
Carron Mfg. Co., 415 S. Aberdeen St., Chicago, Ill.
Control Corp., 600 Stinson Blvd., Minneapolis, Minn.
DX Crystal Co., 1200 N. Claremont Ave., Chicago 22, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electrical Specialty Co., 2304 Washington St., Boston, Mass.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electronic Transformer Co., 207 W. 25th St., New York, N. Y.
Electronic Winding Co., 5031 Broadway, Chicago 40, Ill.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Essex Electronics 1060 Broad St., Newark 2, N. J.
Federal Instrument Co., 3931 47th Ave., Long Island City 4, N. Y.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Franklin Transformer Mfg. Co., 65 22nd Ave., N. E., Minneapolis 13, Minn.
General Electric Co., Schenectady 5, N. Y.
General Winding Co., 420 West 45th St., New York, N. Y.
Guthman & Co., E. L., 15 S. Throop St., Chicago, Ill.
Hammarlund Mfg. Co., Inc., 460 W. 34th St., New York 1, N. Y.
Harvey Radio Laboratories, Inc., 447 Concord Ave., Cambridge, Mass.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
Johnson Co. E. F., Waseca, Minn.
Knickerbocker Development Corp., 116 Little St., Belleville 9, N. J.
Lawton Products Co., Inc., 624 Madison Ave., New York 22, N. Y.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Merit Coil & Transformer Corp., 4427 N. Clark St., Chicago 40, Ill.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
New England Radiocrafters, 1156 Commonwealth Ave., Boston 34, Mass.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
S-W Inductor Co., 1056 N. Wood St., Chicago, Ill.
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J.
Sickles Co., F. W., 165 Front St., Chicopee, Mass.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago 12, Ill.
Sound Equipment Corp. of California, 3903 San Fernando Road, Glendale 4, Calif.
Standard Coil Products Co., 2329 N. Pulaski Rd., Chicago 18, Ill.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Swain Nelson Co., 2320 Glenview Rd., Glenview, Ill.
Teleradio Engineering Corp., 99 Wall St., New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wyse Laboratories, 211 S. Ludlow St., Dayton 2, Ohio

TRANSMITTER TRANSFORMERS

Advance Transformer Co., 14 N. May St., Chicago, Ill.
Airdesign & Fabrication, Inc., 241 Fairfield Ave., Upper Darby, Pa.
American Transformer Co., 178 Emmett St., Newark, N. J.
Audio Development Co., 2833-13th Ave. S., Minneapolis 7, Minn.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Chicago Transformer Div., Essex Wire Corp., 3501 W. Addison St., Chicago 18, Ill.
Davis & Co., Inc., Dean W., Kentland, Ind.
Dinion Coil Co., Inc., Caledonia, N. Y.
Eisler Engineering Co., 740 South 13th St., Newark 3, N. J.
Electricoil Transformer Co., 421 Canal St., New York 13, N. Y.
Electronic Engineering Co., 3223 West Armitage Ave., Chicago, Ill.
Electronic Transformer Co., 207 W. 25th St., New York, N. Y.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.

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Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Ferranti Electric, Inc., 30 Rockefeller Plaza, New York 20, N. Y.
Foster Co., A. P., 719 Wyoming Ave., Lockland 15, Ohio
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
Gardner Electric Mfg. Co., 4227 Hollis St., Emeryville 8, Calif.
General Electric Co., Schenectady 5, N. Y.
Glenn Roberts Co., 3100 East Tenth St., Oakland 1, Calif.
Gramer Co., 2734 N. Pulaski Rd., Chicago 39, Ill.
Hadley Co., Robert M., 711 E. 61st St., Los Angeles, Calif.
Halldorson Company, 4500 Ravenswood Ave., Chicago 28, Ill.
Hercules Electric & Mfg. Co., Inc., 2500 Atlantic Ave., Brooklyn 7, N. Y.
Hudson American Corp., 25 W. 43rd St., New York, N. Y.
Industrial Transformer Corp., 2540 Belmont Ave, New York, N. Y.
International Transformer Co., 396 Broadway, New York, N. Y.
Jefferson Electric Co., Bellwood, Ill.
Kenyon Transformer Co., 840 Barry St., New York 59, N. Y.
Kyle Corp., South Milwaukee, Wisc.
Langevin Co., Inc., 37 West 65th St., New York, N. Y.
Lewyt Corp., 60 Broadway, Brooklyn, N. Y.
Magnetic Windings Co., Div. of Essex Wire Corp., 416 South 16th St., Easton, Pa.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
New York Transformer Co., 26 Waverly Place, New York 3, N. Y.
Newark Transformer Co., 17 Frelinghuysen Ave., Newark, N. J.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Northeifer Winding Labs., 111 Albemarle Ave., Trenton, N. J.
Peerless Electrical Products Co., 6920 McKinley Ave., Los Angeles 1, Calif.
Precision Transformer Co., 733 West Ohio St., Chicago 10, Ill.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radionic Controls, Inc., 3758 Belmont Ave., Chicago, Ill.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Rola Co., Inc., 2530 Superior Ave., Cleveland, Ohio
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J.
Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.
Sorenson & Company, 375 Fairfield Ave., Stamford, Conn.
Standard Electrical Products Co., 400 Linden Ave., Dayton 3, Ohio
Standard Transformer Corp., 1500 N. Halsted St., Chicago, Ill.
Super Electric Products Corp., 1057 Summit Ave., Jersey City, N. J.
Thermador Elec. Mfg. Co., 5119 S. Riverside Drive, Los Angeles 22, Calif.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
Transformer Products, Inc., 143 W. 51st St., New York, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Whisk Laboratories, 87 Maiden Lane, New York 7, N. Y.

VOLTAGE REGULATING TRANSFORMERS

Acme Electric & Mfg. Co., 31 Water St., Cuba, N. Y.
Airdesign & Fabrication, Inc., 241 Fairfield Ave., Upper Darby, Pa.
American Transformer Co., 178 Emmett St., Newark, N. J.
Amplifier Co. of America, 396 Broadway, New York, N. Y.
Davis & Co., Inc., Dean W., Kentland, Ind.
Eisler Engineering Co., 740 South 13th St., Newark 3, N. J.
Electrical Specialty Co., 2304 Washington St., Boston, Mass.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Engineering Co., 3223 W. Armitage Ave., Chicago, Ill.
Electronic Transformer Co., 207 W. 25th St., New York, N. Y.
Ferranti Electric Co., 30 Rockefeller Plaza, New York 20, N. Y.
Freed Transformer Co., 72 Spring St., New York 12, N. Y.
General Electric Co., Schenectady 5, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Gulow Corp., 26 Waverly Place, New York 3, N. Y.
Halldorson Company, 4500 Ravenswood Ave., Chicago 28, Ill.
Industrial Transformer Corp., 2540 Belmont Ave., New York, N. Y.
International Transformer Co., 396 Broadway, New York, N. Y.
National Mineral Co., 2628 N. Pulaski Rd., Chicago 39, Ill.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radionic Transformer Co., 411 S. Sangamon St., Chicago, Ill.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Scientific Electric Div. of "S" Corrugated Quenched Gap Co., 111 Monroe St., Garfield, N. J.
Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.
Sorensen & Co., 375 Fairfield Ave., Stamford, Conn.
Standard Transformer Corp., 1500 N. Halsted St., Chicago, Ill.
Stockwell Transformer Corp., 569 S. Main St., Akron, Ohio
Superior Electric Co., 83 Laurel St., Bristol, Conn.
Thordarson Electric Mfg. Div., Maguire Industries, Inc., 500 W. Huron St., Chicago 10, Ill.
Transformer Products Inc., 143 W. 51st St., New York, N. Y.
United Transformer Corp., 150 Varick St., New York 13, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Whisk Laboratories, 87 Maiden Lane, New York 7, N. Y.

Transmitters

Abbott Instrument Inc., 8 W. 18th St., New York, N. Y.
Aero Communications, Inc., 231 Main St., Hempstead, L. I., N. Y.
Air Associates, Inc., 5827 W. Century Blvd., Los Angeles 45, Calif.
Air Communications, Inc., 2233 Grand Ave., Kansas City 8, Mo.
Air King Products Co., Inc., 1523 63rd St., Brooklyn, N. Y.
Airadio, Inc., Melrose Ave. & Battery Pl., Stamford, Conn.
Aireon Manufacturing Corp., Fairfax & Funston Rds., Kansas City 15, Kansas
Aircraft Radio Corp., Boonton, N. J.
Airplane & Marine Instruments Inc., Clearfield, Pa.
American Communications Corp., 306 Broadway, New York, N. Y.
American Radio Co., 611 E. Garfield Ave., Glendale, Calif.
Arnessen Electric Co., 116 Broad St., New York, N. Y.
Automatic Electric Co., 1033 W. Van Buren St., Chicago 7, Ill.
Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.
Bassett, Inc., Rex., 500 S. E. Second St., Ft. Lauderdale, Fla.
Belmont Radio Corp., 5921 W. Dickens Ave., Chicago, Ill.
Bendix Aviation Corp., Pacific Div., 11600 Sherman Way, North Hollywood, Calif.
Bendix Radio Div., Bendix Aviation Corp., Baltimore 4, Md.
Boehme, Inc., H. O., 915 Broadway, New York, N. Y.
Bunnell & Co., J. H., 215 Fulton St., New York, N. Y.
Collins Radio Co., 855-35th St. N. E., Cedar Rapids, Iowa
Colonial Radio Corp., 254 Rano St., Buffalo 7, N. Y.
Communications Co., Inc., 300 Greco Ave., Coral Gables 34, Fla.
Communication Measurement Laboratory, 120 Greenwich St., New York, N. Y.
Communications Equipment Corp., 134 West Colorado St., Pasadena 1, Calif.
Crosley Corp., 1329 Arlington St., Cincinnati 3, Ohio
Doolittle Radio, Inc., 7421 S. Loomis Blvd., Chicago, Ill.
DuMont Laboratories, Inc., Allen B., 2 Main Ave., Passaic, N. J.
Eckstein Radio & Television Co., 914 La Salle Ave., Minneapolis 2, Minn.
Electronic Corp. of America, 45 West 18th St., New York 11, N. Y.
Electronic Specialty Co., 3456 Glendale Blvd., Los Angeles, Calif.
Erco Radio Labs, Inc., Fenimore Ave., Hempstead, N. Y.
Fada Radio & Electric Co., Inc., 30-20 Thomson Ave., Long Island City, N. Y.
Farnsworth Television & Radio Corp., 3702 Pontiac St., Fort Wayne, Ind.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Fisher Research Laboratory, 1961 University Ave., Palo Alto, Calif.
Foote Pierson & Co., Inc., 75 Hudson St., Newark 4, N. J.
Freed Radio Corp., 200 Hudson St., New York, N. Y.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago 51, Ill.
Garod Radio Corp., 70 Washington St., Brooklyn, N. Y.
Gates Radio Co., 220 Hampshire St., Quincy, Ill.
General Communication Co., 530 Commonwealth Ave., Boston 15, Mass.
General Electric Co., 1 River Rd., Schenectady 5, New York
Grady Instrument Co., 11 Bailey Ave., Watertown 72, Mass.
Gray Radio Co., 730 Okeeshobee Rd., West Palm Beach, Fla.
Hallicrafters Co., 2611 Indiana Ave., Chicago 16, Ill.
Halstead Traffic Communications Corp., 155 E. 44 St., New York, N. Y.
Hamilton Radio Corp., 510 Sixth Ave., New York, N. Y.
Hammarlund Mfg. Co., Inc., 460 W. 34 St., New York 1, N. Y.
Harvey Radio Laboratories, Inc., 447 Concord Ave., Cambridge, Mass.
Harvey-Wells Electronics, Inc., North St., Southbridge, Mass.
Hatcher & Fisk, 125 Kansas Ave., Topeka, Kans.
Hazeltine Electronics Corp., 1775 Broadway, New York, N. Y.
Heath Co., Benton Harbor, Mich.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
Higgins Industries, Inc., 2221 Warwick Ave., Santa Monica, Calif.
Howard Radio Co., 1735 Belmont Ave., Chicago 13, Ill.
Hudson American Corp., 25 W. 43rd St., New York, N. Y.
Islip Radio Mfg. Corp., Foot of Beech St., Islip, New York
Jefferson, Inc., Ray, 40 E. Merrick Rd., Freeport, Long Island, N. Y.
Jefferson-Travis Radio Mfg. Corp., 245 East 23rd Street, New York 10, N. Y.
Johnson, E. F., Co., Waseca, Minn.
Kaar Engineering Co., 619 Emerson St., Palo Alto, Calif.
Lear, Inc., Piqua, Ohio
Lewyt Corp., 60 Broadway, Brooklyn, New York
Link, Fred M., 125 W. 17th St., New York, N. Y.
Majestic Radio & Television Corp., 2600 W. 50th Street, Chicago, Ill.
Meck Industries, John, Plymouth, Ind.
Megard Corp., 1601 S. Burlington St., Los Angeles 6, Calif.
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
Millen Mfg. Co., James, 150 Exchange St., Malden, Mass.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
Oregon Electric Mfg. Co., 206 S. W. Washington St., Portland 4, Oregon
Pacific Electronics, Sprague at Jefferson St., Spokane, Wash.
Packard Bell Co., 1115 So. Hope St., Los Angeles, Calif.
Philharmonic Radio Corp., 528 East 72nd St., New York 21, N. Y.
Press Wireless Inc., 1475 Broadway, New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Radio Craftsmen, 1341 S. Michigan Ave., Chicago, Ill.
Radio Engineering Laboratories, Inc., 35-54 36th St., Long Island City, N. Y.
Radio Laboratories, Inc., 2701 California Ave., Seattle 6, Wash.
Radio Mfg. Engineers, Inc., 304 First Ave., Peoria, Ill.

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ELECTRONIC and ALLIED PRODUCTS

Radio Navigational Instrument Corp., 500 Fifth Avenue, New York, N. Y.
Radio Receptor Co., 251 W. 19th St., New York 11, N. Y.
Radiomarine Corp. of America, 75 Varick St., New York, N. Y.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Scientific Radio Products Co., 738 W. Broadway, Council Bluffs, Iowa
Sheridan Electronics Corp., 2850 S. Michigan Ave., Chicago, Ill.
Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y.
Sonora Radio & Television Corp., 325 N. Hoyne Ave., Chicago 28, Ill.
Sparks-Withington Co., 2400 E. Ganson St., Jackson, Mich.
Taybern Equipment Co., 120 Greenwich St., New York 6, N. Y.
Technical Devices Corp., Beaufort & Eagle Rock Aves., Roseland, N. J.
Technical Radio Co., 275 Ninth St., San Francisco, Calif.
Telephonics Corp., 350 West 31st St., New York 1, N. Y.
Televiso Products Inc., 6533 N. Olmsted Ave., Chicago, Ill.
Templetone Radio Mfg. Corp., New London, Conn.
Transmitter Equipment Mfg. Co. Inc., 345 Hudson St., New York 14, N. Y.
U. S. Television Manufacturing Corp., 106 Seventh Ave., New York 11, N. Y.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Westinghouse Electric & Mfg. Co., Electronics & X-Ray Divisions, Baltimore 3, Md.
Wilcox Electric Co., 1400 Chestnut St., Kansas City, Mo.
Wilcox Gay Corp., Charlotte, Mich.
Winters & Crampton Corp., 150 Wilson Ave., Grandville, Mich.

AIRCRAFT TRANSMITTERS

Air Communications, Inc., Kansas City 8, Mo.
Bendix Radio Corp., Baltimore 3, Md.
Collins Radio Co., Cedar Rapids, Iowa
Gates Radio & Supply Co., Quincy, Ill.
General Electric Co., Bridgeport, Conn.
Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Herbach & Rademan Co., 517 Ludlow St., Philadelphia 6, Pa.
Lear, Inc., Piqua, Ohio
Midwest Radio Corp., 909 Broadway, Cincinnati, Ohio
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., 60 East 42nd St., New York 17, N. Y.
Searle Aero Industries, Inc., Orange, Calif.
Western Electric Co., 120 Broadway, New York, N. Y.
Westinghouse Electric Corp., 2511 Wilkens Ave., Baltimore 3, Md.

RAILROAD TRANSMITTERS

Aireon Mfg. Co., Fairfax & Funston Rd., Kansas City 15, Kans.
Bendix Radio Corp., Baltimore 4, Md.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
Galvin Mfg. Corp., 4545 Augusta Blvd., Chicago, Ill.
General Electric Co., Bridgeport, Conn.
Hallicrafters Co., 2611 S. Indiana Ave., Chicago, Ill.
Herbach & Rademan Co., 517 Ludlow St., Philadelphia 6, Pa.
Medco Mfg. Co., 5 West 45th St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., 60 East 42nd St., New York 17, N. Y.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.

TELEVISION TRANSMITTERS

DuMont Laboratories, Inc., Allen B., 2 Main Ave., Passaic, N. J.
Farnsworth Television & Radio Corp., 3700 Pontiac St., Fort Wayne, Ind.
General Electric Co., Bridgeport, Conn.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Western Electric Co., 120 Broadway, New York, N. Y.
Westinghouse Electric Corp., 2519 Wilkens Ave., Baltimore 3, Md.

Tubes

CATHODE RAY TUBES

DuMont Laboratories, Inc., Allen B., 2 Main Ave., Passaic, N. J.
Electronic Tube Corp., 1200 E. Mermaid Ave., Chestnut Hill, Philadelphia, Pa.
Farnsworth Television Radio Corp., 3702 Pontiac St., Fort Wayne, Ind.
General Electric Co., Schenectady 5, New York
Ken-Rad Div., General Electric Co. Electronics Dept., Owensboro, Ky.
Lenoxite Div., Lenox Inc., 65 Prince St., Trenton 5, N. J.
Lewis Electronics, Inc., Los Gatos, Calif.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
North American Philips Co., 100 East 42nd St., New York 17, N. Y.
Philco Corp., Tioga & C Sts., Philadelphia 34, Pa.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.
Standard Arcturus Corp., 30 Court St., Newark 2, N. J.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York, N. Y.
Western Electric Co., 120 Broadway, New York 5, N. Y.

CURRENT REGULATING TUBES (Ballast)

Amperite Co., 561 Broadway, New York, N. Y.
Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn 1, N. Y.
Continental Electric Co., 903 Merchandise Mart, Chicago 54, Ill.
Electronic Enterprises, Inc., 65-67 Seventh Ave., Newark 4, N. J.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
General Electric Co., Schenectady 5, N. Y.
Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass.
J.F.D. Mfg. Co., 4111 Fort Hamilton Pkwy., Brooklyn, N. Y.
Magnetic Windings Co., Div. of Essex Wire Corp., 416 South 16th St., Easton, Pa.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Muter Co., 1255 S. Michigan Ave., Chicago, Ill.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Smith Mfg. Co., Nathan R., 105 Pasadena Ave., South Pasadena, Calif.
Standard Arcturus Corp., 30 Court St., Newark 2, N. J.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago 47, Ill.
Western Electric Co. Inc., 120 Broadway, New York, N. Y.
Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

GEIGER-MUELLER TUBES and EQUIPMENT

Aerolux Light Corp., 653-11th Ave., New York 19, N. Y.
Cyclotron Specialties Co., Moraga, Calif.
Distillation Products Co., 1755 Ridge Road W., Rochester, N. Y.
General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.
Geophysical Instrument Co., Key Blvd. & Nash St., Arlington, Va.
Herbach & Rademan Co., Mfg. Div., 517 Ludlow St., Philadelphia 6, Pa.
North American Philips Co., 100 East 42nd St., New York 17, N. Y.
Universal X-Ray Products, Inc., 1800 North Francisco Ave., Chicago 47, Ill.
Westinghouse Electric Corp., E. Pittsburgh, Pa.

HEARING AID TUBES

Aurex Corp., 1117 N. Franklin St., Chicago 10, Ill.
Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass.
Ken-Rad Div., General Electric Co., Electronics Dept., Owensboro, Ky.
Myers & Sons, E. A., Radioear Bldg., Mt. Lebanon, Pittsburgh, Pa.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Sonotone Corp., P. O., Box 200, Saw Mill River Rd., Elmsford, N. Y.
Standard Arcturus Corp., 30 Court St., Newark 2, N. J.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

INDUSTRIAL TUBES

Aerolux Light Corp., 653 Eleventh Ave., New York 19, N. Y.
Amperex Electronic Co., 79 Washington St., Brooklyn, N. Y.
Chatham Electronics, 475 Washington St., Newark 2, N. J.
Continental Electric Co., 903 Merchandise Mart, Chicago 54, Ill.
Controls Corp., 98 Union St., Worcester 8, Mass.
Eitel-McCullough, Inc., San Bruno, Calif.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Enterprises, Inc., 65-67 Seventh Ave., Newark 4, N. J.
Electronic Products Co., 111 E. Third St., Mt. Vernon, N. Y.
Electrons, Inc., 127 Sussex Ave., Newark, N. J.
Farnsworth Television & Radio Corp., 3702 Pontiac St., Fort Wayne, Ind.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
Fredericks Co., Geo. E. Bethayres, Pa.
General Electric Co., Schenectady 5, N. Y.
General Electronics, Inc., 1819 Broadway, New York 23, N. Y.
Hanovia Chemical & Mfg. Co., 233 N. J. R. R. Ave., Newark, N. J.
Heintz & Kaufman, Ltd., South San Francisco, Calif.
Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Calif.
Ken-Rad Div., General Electric Co. Electronics Dept., Owensboro, Ky.
Litton Engineering Labs., Redwood City, Calif.
Machlett Laboratories, Springdale, Conn.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
North American Philips Co., 100 E. 42nd St., New York, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Slater Elec. & Mfg. Co., Inc., 728 Atlantic Ave., Brooklyn 17, N. Y.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Standard Arcturus Corp., 30 Court St., Newark 2, N. J.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago 47, Ill.
United Electronics Co., 42 Spring St., Newark 2, N. J.
Universal X-Ray Products, Inc., 1800 North Francisco Ave., Chicago 47, Ill.
Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.

PHOTOTUBES & PHOTOCELLS

Aray Mfg. & Supply Co., 3107 Pine St., St. Louis 3, Mo.
Bradley Laboratories, 82 Meadow St., New Haven, Conn.
Continental Electric Co., 903 Merchandise Mart, Chicago 54, Ill.
DeJur Amsco Corp., Northern Blvd. at 45th St., Long Island City 1, N. Y.
Eby, Inc., Hugh H., 18 W. Chelton Ave., Philadelphia 13, Pa.
Eisler Engineering Co., 740 South 13th St., Newark 3, N. J.
G-M Laboratories, Inc., 4313 N. Knox Ave., Chicago 32, Ill.
General Electric Co., Schenectady 5, N. Y.
General Scientific Corp., 4829 S. Kedzie Ave., Chicago, Ill.
Hickok Electrical Instrument Co., 10514 DuPont Ave., Cleveland, Ohio

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Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Pfaltz & Bauer, Inc., 350 Fifth Ave., New York, N. Y.
Photovolt Corp., 95 Madison Ave., New York 16, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rauland Corp., 4245 N. Knox Ave., Chicago 41, Ill.
Rehtron Corp., 4313 Lincoln Ave., Chicago 18, Ill.
Selenium Corp. of America, 1719 W. Pico Blvd., Los Angeles 15, Calif.
Standard Arcturus Corp., 30 Court St., Newark 2, N. J.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Lamp Div., Westinghouse Electric & Mfg. Co., Bloomfield, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Weston Electrical Instrument Corp., 614 Frelinghuysen Ave., Newark 5, N. J.

RECEIVING TUBES

Admiral Corp., 3800 W. Cortland St., Chicago 11, Ill.
Emerson Radio & Phonograph Corp., 111 Eighth Ave., New York, N. Y.
General Electric Co., Schenectady 5, New York
Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass.
Ken-Rad Div., General Electric Co., Electronics Dept., Owensboro, Ky.
Magnavox Co., The, 2131 Bueter Rd., Fort Wayne 4, Ind.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
Philco Corp., Tioga & C Sts., Philadelphia, 34, Pa.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Slater Electric & Mfg. Co., Inc., 728 Atlantic Ave., Brooklyn 17, N. Y.
Standard Arcturus Corp., 30 Court St., Newark 2, N. J.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Tung-Sol Lamp Works Inc., 95 Eighth Ave., Newark, N. J.
Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio
Western Electric Co., Inc., 120 Broadway, New York, 5, N. Y.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

RECTIFYING TUBES

Amperex Electronic Corp., 25 Washington St., Brooklyn, N. Y.
Chatham Electronics, 475 Washington St., Newark 2, N. J.
Continental Electric Co., 903 Merchandise Mart, Chicago 54, Ill.
Eitel-McCullough, Inc., San Bruno, Calif.
Electric Heat Control Co., 9123 Inman Ave., Cleveland 5, Ohio
Electronic Products Co., 111 E. Third St., Mt. Vernon, N. Y.
Electrons, Inc., 127 Sussex Ave., Newark, N. J.
Federal Engineering Co., 37 Murray St., New York 7, N. Y.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
General Electric Co., Schenectady 5, N. Y.
General Electric X-Ray Corp., 2012 Jackson Blvd., Chicago, Ill.
General Electronics, Inc., 1819 Broadway, New York 23, N. Y.
Heintz & Kaufman, Ltd., South San Francisco, Calif.
Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass.
Industrial & Commercial Electronics, Belmont, Calif.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Calif.
Machlett Laboratories, Springdale, Conn.
Mellaphone Corp., Rochester 2, N. Y.
National Co., Inc., 61 Sherman St., Malden 48, Mass.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
North American Philips Co., 100 East 42nd St., New York 17, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Slater Electric & Mfg. Co., Inc., 728 Atlantic Ave., Brooklyn 17, N. Y.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Standard Arcturus Corp., 30 Court St., Newark 2, N. J.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago 47, Ill.
Translite, Inc., 647 Kent Ave., Brooklyn, N. Y.
United Electronics Co., 42 Spring St., Newark 2, N. J.
Universal X-Ray Products, Inc., 1800 North Francisco Ave., Chicago 47, Ill.
Victoreen Instrument Co., 5806 Hough Ave., Cleveland 3, Ohio
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.
Zenith Radio Corp., 6001 Dickens Ave., Chicago, Ill.

TRANSMITTING and POWER TUBES

Amperex Electronic Corp., 25 Washington St., Brooklyn, N. Y.
Chatham Electronics, 475 Washington St., Newark 2, N. J.
Controls Corp., 98 Union St., Worcester 8, Mass.
de Forest Laboratories, Lee, 5106 Wilshire Blvd., Los Angeles, Calif.
Eitel-McCullough, Inc., San Bruno, Cal.
Electron Equipment Corp., 917 Meridian Ave., South Pasadena, Calif.
Electronic Enterprises, Inc., 65-67 Seventh Ave., Newark 4, N. J.
Electronic Products Co., 111 E. Third St., Mt. Vernon, N. Y.
Electronic Tube Corp., 1200 E. Mermaid Ave., Chestnut Hill, Philadelphia, Pa.
Federal Engineering Co., 37 Murray St., New York 7, N. Y.
Federal Telephone and Radio Corp., 591 Broad St., Newark, N. J.
General Electric Co., Schenectady 5, New York
General Electronics, Inc., 1819 Broadway, New York 23, N. Y.
Heintz & Kaufman, Ltd., South San Francisco, Calif.
Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass.
Industrial & Commercial Electronics, Belmont, Calif.
Jennings Radio Mfg. Co., 1098 E. William St., San Jose 12, Calif.
Ken-Rad Div., General Electric Co., Electronics Dept., Owensboro, Ky.
Lewis Electronics, Inc., Los Gatos, Calif.
Litton Engineering Labs., P. O. Box 749, Redwood City, Calif.
Machlett Laboratories, Springdale, Conn.
National Union Radio Corp., 15 Washington St., Newark 2, N. J.
North American Philips Co., Inc., 100 East 42nd St., New York 17, N. Y.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Raytheon Mfg. Co., Foundry Ave., Waltham, Mass.
Slater Electric & Mfg. Co., Inc., 728 Atlantic Ave., Brooklyn 17, N. Y.
Sperry Gyroscope Co., Manhattan Bridge Plaza, Brooklyn 1, N. Y.
Sperti, Inc., Norwood Station, Cincinnati 12, Ohio
Standard Arcturus Corp., 30 Court St., Newark 2, N. J.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago 47, Ill.
Tung-Sol Lamp Works, Inc., 95 Eighth Ave., Newark, N. J.
United Electronics Co., 42 Spring St., Newark 2, N. J.
Western Electric Co., Inc., 120 Broadway, New York 5, N. Y.
Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.

VOLTAGE REGULATING TUBES

see Rectifying Tubes

X-RAY TUBES and EQUIPMENT

Eureka X-Ray Corp., 3250 N. Kilpatrick St., Chicago, Ill.
Fischer & Co., H. G., 2323 Wabansia Ave., Chicago 47, Ill.
Franklin X-Ray Co., 2100 Arch St., Philadelphia 3, Pa.
General Electric Co., Schenectady 5, N. Y.
General Electric X-Ray Corp., 2012 Jackson Blvd., Chicago, Ill.
Machlett Laboratories, Springdale, Conn.
Newman X-Ray Corp., 518 Hankes Ave., Aurora, Ill.
North American Philips Co., Inc., Metallix Div., 100 East 42nd St., New York, N. Y.
Peerless Laboratories, 461 Tenth Ave., New York 18, N. Y.
Picker X-Ray Corp., 300 Fourth Ave., New York 10, N. Y.
Standard X-Ray Co., 1932 North Burling St., Chicago 14, Ill.
Universal X-Ray Products, Inc., 1800 N. Francisco Ave., Chicago 47, Ill.
Westinghouse Electric Corp., Industrial Electronics & X-Ray Divs. Baltimore 3, Md.
Westinghouse Electric Corp., Lamp Div., Bloomfield, N. J.
Westinghouse Electric Corp., East Pittsburgh, Pa.

Tube Manufacturers—Test Equipment

Sherron Electronics Co., 1201 Flushing Ave., Brooklyn 6, N. Y.

Tube Making Machines

see Machines, Tube Making

Tube Parts

Admak Manufacturing Co., 46 Cordier St., Irvington, N. J.
American Brass Co., Waterbury 88, Conn.
Art Wire & Stamping Co., 227 High St., Newark 2, N. J.
Bead Chain Mfg. Co., 110 Mt. Grove St., Bridgeport 5, Conn.
Callite Tungsten Corp., 544 39th St., Union City, N. J.
Electronic Manufacturing Co., 20 Orange St., Newark 2, N. J.
Electronic Products Co., 111 E. Third St., Mt. Vernon, N. Y.
Engineering Co., 27 Wright St., Newark, N. J.
Fansteel Metallurgical Corp., 2200 Sheridan Road, North Chicago, Ill.
Ford Radio & Mica Corp., 538 63rd St., Brooklyn, N. Y.
General Electric Co., Schenectady 5, N. Y.
Goat Metal Stampings, Inc., 314 Dean St., Brooklyn, N. Y.
Haydu Bros., Mt. Bethel Rd., Plainfield, N. J.
Huse Liberty Mica Co., 171 Camden St., Boston, Mass.
King Laboratories, Inc., 205 Oneida Street, Syracuse 4, N. Y.
Lewis Electronics Inc., Los Gatos, Calif.
Litton Engineering Labs., P. O. Box 749, Redwood City, Calif.
Makepeace Co., D. E., Attleboro, Mass.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Munsell & Co., Eugene, 200 Varick St., New York, N. Y.
National Carbon Co. Inc., 30 East 42nd St., New York 17, N. Y.
Northern Mfg. Co., Inc., 36 Spring St., Newark, N. J.
Pierce Paper Products Co., Rockford, Ill.
Radio Corp. of America, R.C.A. Victor Div., Camden, N. J.
Rice's Sons, Inc., Bernard, 325 Fifth Ave., New York, N. Y.
Springfield Sound Co., Electronics Div., 12 Cass St., Springfield, Mass.
Superior Tube Co., Norristown, Pa.
Thompson Corp., Geo. S., 5240 Huntington Drive, Los Angeles 32, Calif.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
United-Carr Fastener Corp., 31 Ames St., Cambridge, Mass.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Wickwire Spencer Metallurgical Corp., 260 Sherman St., Newark 2, N. J.
Worcester Pressed Steel Co., 100 Barber Ave., Worcester, Mass.

Tube Repairs

Electronic Products Co., 111 E. Third St., Mt. Vernon, N. Y.
Freeland & Olschner Products, Inc., 611 Baronne St., New Orleans 13, La.

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Lewis Electronics, Inc., Los Gatos, Calif.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
West Shore Laboratories, Box 117, Marblehead. Mass.

Tubing

BRASS and COPPER TUBING

American Brass Co., Waterbury 88, Conn.
Bridgeport Brass Co., E. Main St., Bridgeport, Conn.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Edwards, Inc., T. J., 121 Beach St., Boston 5, Mass.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Ilsco Copper Tube & Product Inc., Mariemont 27, Ohio
Precision Tube Co., 3828 Terrace St., Philadelphia 28, Pa.
Revere Copper & Brass Inc., 230 Park Ave., New York 17, N. Y.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Uniform Tubes, Shurs Lane & Lauriston St., Roxborough, Philadelphia, Pa.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Wolverine Tube Co. Div., Calumet & Hecla Consolidated Copper Co., 1411 Central Ave., Detroit 9, Mich.

CERAMIC TUBING

see Insulation

FABRIC TUBES and TUBING

Alpha Wire Corp., 50 Howard St., New York, N. Y.
Anchor Webbing Co., 1005 Main St., Pawtucket, R. I.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Brand & Co., William, 276 Fourth Ave., New York 10, N. Y.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Bridgeport, Conn.
Hope Webbing Co., Providence, Rhode Island
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
McInerny Plastics Co., 655 Godfrey Ave., S. W., Grand Rapids 1, Mich.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
National Varnished Products Corp., 211 Randolph Ave., Woodbridge, N. J.
Penn Fibre & Specialty Co., 2030 E. Westmoreland St., Philadelphia 34, Pa.
Surprenant Electrical Insulation Co., 84 Purchase St., Boston 10, Mass.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
Varflex Corp., N. Jay St., Rome, N. Y.

FIBRE TUBING

see Insulation

GLASS TUBES and TUBING

Aeroiux Light Corp., 653-11th Ave., New York 19, N. Y.
Alpha Wire Corp., 50 Howard St., New York, N. Y.
B. & C. Insulation Products, Inc., 261 Fifth Ave., New York 16, N. Y.
Bache & Co., Semon, 636 Greenwich St., New York 14, N. Y.
Bentley, Harris Mfg. Co Hector & Lime Sts., Conshohocken, Pa.
Brand & Co., William, 276 Fourth Ave., New York 10, N. Y.
Corning Glass Works, Corning, N. Y.
Fisher Scientific Co., 711 Forbes St., Pittsburgh, Pa.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Goodall Electric Mfg. Co., 320 N. Spruce St., Ogallala, Nebr.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Libbey Glass Div. Owens-Illinois Glass Co., P. O. Box 1035-36, Toledo 1, Ohio
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Varflex Corp., N. Jay St., Rome, N. Y.

KNITTED WIRE TUBES and TUBING

Alden Products Co., 117 North Main St., Brockton 64, Mass.
Alpha Wire Corp., 50 Howard St., New York, N. Y.
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Chicago Metal Hose Corp., 1315 S. 3rd Ave., Maywood, Ill.
Electric Auto-Lite Co., Toledo 1, Ohio
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
General Electric Co., Schenectady 5, N. Y.

METAL and ALLOY TUBING

American Brass Co., Waterbury 88, Conn.
General Plate Div., Metals & Controls Corp., 34 Forest St., Attleboro, Mass.
International Nickel Co., 67 Wall St., New York 5, N. Y.
Johnson Co. E. F., Waseca, Minn.
Makepeace Co., D. E., Attleboro, Mass.
National Lead Co., 111 Broadway, New York 6, N. Y.
Precision Tube Co., 3828 Terrace St., Philadelphia 28, Pa.
Revere Copper & Brass Inc., 230 Park Ave., New York 17, N. Y.
Summerill Tubing Co., Montgomery County, Bridgeport, Pa.
Superior Tube Co., Norristown, Pa.
Swedish Iron & Steel Corp., 17 Battery Place, New York, N. Y.
Uniform Tubes, Shurs Lane & Lauriston St., Roxborough, Philadelphia, Pa.
Westinghouse Electric Corp., East Pittsburgh, Pa.

PAPER TUBES and TUBING

American Paper Tube Co., Hazel St., Woonsocket, R. I.
B. & C. Insulation Products Inc., 261 Fifth Ave., New York 16, N. Y.
Bentley Harris Mfg. Co., Hector & Lime Sts., Conshohocken, Pa.
Creative Plastics Corp., 963 Kent Ave., Brooklyn, N. Y.
Cross Paper Products Corp., 2595 Third Ave., New York, N. Y.
Franklin Fibre-Lamitex Corp., 12th & French Sts., Wilmington, Del.
General Electric Co., Bridgeport, Conn.
General Paper Tube Co., 430 E. Chelton Ave., Philadelphia, Pa.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Mica Products Mfg. Co., 69 Wooster St., New York, N. Y.
Paramount Paper Tube Co., 801 Glasgow Ave., Fort Wayne, Ind.
Pierce Paper Products Co., Rockford, Ill.
Precision Paper Tube Co., 2033 W. Charleston St., Chicago 47, Ill.
Tingstol Corp., 1461 W. Grand Ave., Chicago, Ill.
Westinghouse Electric Corp., East Pittsburgh, Pa.

PLASTIC TUBING

see Insulation

Turntables

PHONOGRAPH and TRANSCRIPTION TURNTABLES

Alliance Mfg. Co., Lake Park Blvd., Alliance, Ohio
Allied Recording Products Co., 21-09 43rd Ave., Long Island City 1, N. Y.
Chicago Sound Systems Co., 2124 S. Michigan Ave., Chicago, Ill.
Electro Acoustic Co., 2131 Bueter Rd., Fort Wayne, Ind.
Gates Radio Co., 200 Hampshire St., Quincy, Ill.
General Electric Co., Schenectady 5, N. Y.
Harris Mfg. Co., 2422 W. Seventh St., Los Angeles 5, Calif.
Merkle-Korff Gear Co., 213 N. Morgan St., Chicago 7, Ill.
Newcomb Audio Products Co., 2815 S. Hill St., Los Angeles, Calif.
Northern Communications Mfg. Co., 210 East 40th St., New York, N. Y.
Pacific Sound Equipment Co., 1534 Cahuenga Blvd., Hollywood, Calif.
Presto Recording Corp., 242 W. 55th St., New York, N. Y.
Proctor Co., B. A., Inc., 2 W. 45th St., New York, N. Y.
Radiad Service, 720 West Schubert Ave., Chicago 14, Ill.
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Rek-O-Kut Co., 173 Lafayette St., New York 13, N. Y.
Robinson Recording Laboratories, 35 S. Ninth St., Philadelphia, Pa.
Talking Devices Co., 4447 W. Irving Park Rd., Chicago, Ill.
United Cinephone Corp., 65 New Litchfield St., Torrington, Conn.
Webster Chicago Corp., Electronics Div., 3825 Armitage Ave., Chicago, Ill.

Varnish

see Finishes

Vibration Insulating Mountings

see Mountings

Vibrator Testers

see Testers, Vibration

Vibrators

Allis Chalmers Mfg. Co., Milwaukee, Wisc.
American Television & Radio Co., 300 E. Fourth St., St. Paul, Minn.
Collins Radio Co., 855 35th St., N. E., Cedar Rapids, Iowa
Ecco High Frequency Electric Corp., 7020 Hudson Blvd., North Bergen, N. J.
Electric Specialty Co., 211 South St., Stamford, Conn.
Electronic Laboratories, Inc., Indianapolis, Ind.
Electronic Products Mfg. Co., 7300 Huron River Drive, Dexter, Mich.
Fidelity Electric Co., 332 N. Arch St., Lancaster, Pa.
General Electric Co., Schenectady 5, N. Y.
James Vibrapowr Co., 1551 Thomas St., Chicago 22, Ill.
Kurman Electric Co., 35-18 37th St., Long Island City 1, N. Y.
Mallory & Co., Inc., P. R., 3029 E. Washington St., Indianapolis 6, Ind.
Oak Mfg. Co., 1260 Clybourn Ave., Chicago 10, Ill.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Radiart Corp., 3571 West 62nd St., Cleveland 2, Ohio
Radio Corp. of America, RCA Victor Div., Camden, N. J.
Richardson-Allen Corp., 15 West 20th St., New York 11, N. Y.
Turner Co., 909 17th St., Cedar Rapids, Iowa
Utah Radio Products Co., 820 Orleans St., Chicago, Ill.
Wilcox Gay Corp., Charlotte, Mich.

Voltage Dividers

see Dividers

Voltage Regulators

see Regulators

Voltmeter Multipliers

see Multipliers

Voltmeters

see Meters

Volume Controls

see Controls

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Washers

LOCK WASHERS

American Nut & Bolt Fastener Co., 2045 Doerr St., Pittsburgh, Pa.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Clark Bros. Bolt Co., Millidale, Conn.
Federal Screw Products Co., 224 W. Huron St., Chicago 10, Ill.
Garrett Co., Inc., Geo. K., 1421 Chestnut St., Philadelphia 2, Pa.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
Harper Co., H. M., 2620 Fletcher St., Chicago 18, Ill.
Hartford Machine Screw Co., Hartford, Conn.
Industrial Screw & Supply Co., 713 W. Lake St., Chicago 6, Ill.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
Manufacturers Screw Products, 270 W. Hubbard St., Chicago, Ill.
National Lock Washer Co., 40 Hermon St., Newark 5, N. J.
Palnut Co., Inc., 77 Cordier St., Irvington, 11, N. J.
Penn Fibre & Specialty Co., 2030 E. Moreland St., Philadelphia 44, Pa.
Philadelphia Steel & Wire Corp., Penn St. & Belfield Ave., Philadelphia, Pa.
Positive Lock Washer Co., 181 Miller St., Newark, N. J.
Printloid, Inc., 95 Mercer St., New York 12, N. Y.
Quadriga Mfg. Co., 213 W. Grand Ave., Chicago 11, Ill.
St. Louis Screw & Bolt Co., 6900 N. B'way, St. Louis 15, Mo.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Scovill Mfg. Co., 99 Mill St., Waterbury 91, Conn.
Shakeproof, Inc., 2501 N. Keeler Ave., Chicago 39, Ill.
Spaulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y.
Standard Locknut & Lockwasher Inc., 33-35 W. St. Clair St., Indianapolis 4, Ind.
Sterling Bolt Co., 209 W. Jackson Blvd., Chicago, Ill.
Thompson-Bremer & Co., 1640 W. Hubbard St., Chicago, Ill.
Worcester Pressed Steel Co., 100 Barber Ave., Worcester, Mass.
Wrought Washer Mfg. Co., 2100 S. Bay St., Milwaukee 7, Wis.

Wattmeters

see Meters

Waxes

WAX, RUBBER, ASPHALTUM, OR OTHER BASE INSULATING COMPOUNDS

Allied Asphalt & Mineral Corp., 217 Broadway, New York, N. Y.
American Phenolic Corp., Chicago, Ill.
American Products Mfg. Co., 8127 Oleander St., New Orleans, La.
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Austin Co., M. B., 108 S. Desplaines St., Chicago, Ill.
Bakelite Corp., Unit of Union Carbide & Carbon Corp., 30 East 42nd St., New York 17, N. Y.
Biddle Co., James G., 1213 Arch St., Philadelphia, Pa.
Biwax Corp., 3445 Howard St., Skokie, Ill.
Candy & Co., 2515 West 35th St., Chicago, Ill.
Cantol Wax Co., 211 N. Washington St., Bloomington, Ind.
Cochrane Chemical Co., 432 Danforth Ave., Jersey City, N. J.
Communication Parts, 1101 N. Paulina St., Chicago 22, Ill.
Dolph Co., John, 1060 Broad St., Newark, N. J.
Dow Corning Corp., Box 592, Midland, Mich.
duPont de Nemours & Co., E. I., Plastics Dept., 626 Schuyler Ave., Arlington, N. J.
Electrical Engineers Equipment Co., Melrose Park, Ill.
Federal Telephone & Radio Corp., 591 Broad St., Newark, N. J.
G & W Electric Specialty Co., 7800 Kenwood Ave., Chicago, Ill.
General Cable Corp., 420 Lexington Ave., New York, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockford, Ill.
General Electric Co., Schenectady 5, N. Y.
George Co., P. D., 4153 Bingham Ave., St. Louis, Mo.
Georgia Rosin Products Co., Savannah, Ga.
Glyco Products Co., Inc., 26 Court St., Brooklyn, N. Y.
Goodrich Chemical Co., B. F., Rose Bldg., Cleveland, Ohio
Impervious Varnish Co., Rochester, Pa.
Insl-X Co., Inc., 857 Meeker Ave., Brooklyn, N. Y.
Insulatine Co., 1 Broadway, New York, N. Y.
Insulation Manufacturers Corp., 565 W. Washington Blvd., Chicago 6, Ill.
Irvington Varnish & Insulator Co., 10 Argyle Terrace, Irvington 11, N. J.
Johns-Manville, 22 East 40th St., New York, N. Y.
Johnson & Co., S. C., Industrial Div., Racine, Wisc.
Line Material Co., 740 North 2nd St., Milwaukee, Wisc.
McGill Mfg. Co., Box 670, Valparaiso, Ind.
Mica Insulator Co., 797 Broadway, Schenectady 1, N. Y.
Minerallac Electric Co., 25 N. Peoria St., Chicago, Ill.
Mitchell-Rand Insulation Co., Inc., 51 Murray St., New York 7, N. Y.
National Electric Products Corp., Fulton Bldg., Pittsburgh, Pa.
Nukem Products Corp., 70 Niagara St., Buffalo, N. Y.
Paisley Products, Inc., 1770 Canalport Ave., Chicago 16, Ill.
Okonite Co., Canal St., Passaic, N. J.
Pioneer Asphalt Co., 435 N. Michigan Ave., Chicago, Ill.
Production Engineering Corp., 666 Van Houten Ave., Clifton, N. J. (service)
Robertson Chemical Co., 9808 Meech Ave., Cleveland, Ohio
Rockbestos Products Corp., 310 Nicoll St., New Haven, Conn.
Roebling's Sons Co., John A., 640 S. Broad St., Trenton, N. J.
Ruberoid Co., 500 Fifth Ave., New York, N. Y.
Rusgreen Mfg. Co., 14262 Birwood Ave., Detroit, Mich.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Sauereisen Cement Co., Sharpsburg Station, Pittsburgh, Pa.
Standard Oil Co. (Indiana), 910 S. Michigan Ave., Chicago 80, Ill.
Sterling Varnish Co., Haysville, Pa.
Standard Varnish Works, 2600 Richmond Terrace, Staten Island 3, N. Y.
Trotter & Co., E. T., 594 Johnson Ave., Brooklyn, N. Y.
United States Rubber Co., 1230 Sixth Ave., New York, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Witco Chemical Co., 295 Madison Ave., New York 17, N. Y.
Zophar Mills, Inc., 112 26th St., Brooklyn 32, N. Y.

Welding Controls & Timers

see Timers, Welding

Winders

COIL WINDERS

see Machines

WINDINGS

see Coils

Wire

ANTENNA WIRE

Alpha Wire Corp., 50 Howard St., New York, N. Y.
American Brass Co., Waterbury 88, Conn.
American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Ansonia Electrical Co., Ansonia, Conn.
Belden Mfg. Co., 4647 W. Van Buren St., Chicago 44, Ill.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Boston Insulated Wire & Cable Co., 65 Bay St. (Dorchester), Boston, Mass.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Columbia Wire & Supply Co., 4106 N. Pulaski Road, Chicago 41, Ill.
Crescent Insulated Wire & Cable Co., N. Olden Ave., Trenton, N. J.
Diamond Wire & Cable Co., 128 E. 16th St., Chicago Heights, Ill.
Eagle Electric Mfg. Co. Inc., 23-10 Bridge Plaza S., Long Island City, N. Y.
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Electric Auto-Lite Co., Toledo 1, Ohio
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
Fleron & Son, Inc., M. M., 113 N. Broad St., Trenton, N. J.
Flexo Wire Co., 638 Genessee St. W., Syracuse 1, N. Y.
General Cable Corp., 420 Lexington Ave., New York, N. Y.
General Electric Co., Schenectady 5, N. Y.
Johnson Co., E. F., Waseca, Minn.
New England Electrical Wks., Inc., 365 Main St., Lisbon, N. H.
Paranite Wire & Cable Div. of Essex Wire Corp., 1601 Wall St., Fort Wayne 6, Ind.
Roebling's Sons Co., John A., 640 S. Broad St., Trenton 2, N. J.
Schott Co., Walter L., 9306 Santa Monica Blvd., Beverly Hills, Calif.
Spencer Wire Co., West Brookfield, Mass.
Uniform Tubes, Shurs Lane & Lauriston St., Roxborough, Philadelphia, Pa.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Westinghouse Lamp Div., Westinghouse Electric Corp., Bloomfield, N. J.

HIGH VOLTAGE WIRE

Alden Products Co., 117 North Main St., Brockton 64, Mass.
Alpha Wire Corp., 50 Howard St., New York, N. Y.
American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Boston Insulated Wire & Cable Co., 65 Bay St., Dorchester, Boston, Mass.
Columbia Wire & Supply Co., 4106 North Pulaski Road, Chicago 41, Ill.
Crescent Co., Inc., Front & Central Ave., Pawtucket, R. I.
Crescent Insulated Wire & Cable Co., N. Olden Ave., Trenton, N. J.
Diamond Wire & Cable Co., 128 E. 16th St., Chicago Heights, Ill.
Electric Auto-Lite Co., Toledo 1, Ohio
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
Flexo Wire Co., 638 Genesee St. W., Syracuse 1, N. Y.
General Cable Corp., 420 Lexington Ave., New York, N. Y.
General Electric Co., Bridgeport, Conn.
General Electric Co., Schenectady, N. Y.
Goldmark Wire Co., James, 116 West St., New York 7, N. Y.
Lenz Electric Mfg. Co., 1751 N. Western Avenue, Chicago 47, Ill.
National Electric Products Corp., Fulton Bldg., Pittsburgh, Pa.
Okonite Co., Canal St., Passaic, N. J.
Phelps Dodge Copper Products Corp., American Copper Prods. Div., 40 Wall St., New York, N. Y.
Rhode Island Insulated Wire Co., 50 Burnham Ave., Providence, R. I.
Roebling's Sons Co., John A., 640 S. Broad St., Trenton 2, N. J.
Rome Cable Corp., 330 Ridge St., Rome, N. Y.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Western Insulated Wire, Inc., 1151 South Broadway, Los Angeles 15, Calif.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

HOOKUP WIRE

Acorn Insulated Wire Co., Inc., 225 King St., Brooklyn 31, N. Y.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
Alpha Wire Corp., 50 Howard St., New York, N. Y.
American Electric Cable Co., Holyoke, Mass.
American Phenolic Corp., 1830 S. 54 Chicago 50, Ill.

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American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Ansonia Electrical Co., Ansonia, Conn.
Belden Mfg. Co., 4647 W. Van Buren St., Chicago 44, Ill.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Boston Insulated Wire & Cable Co., 65 Bay St., (Dorchester), Boston, Mass.
Columbia Wire & Supply Co., 4106 N. Pulaski Road, Chicago 41, Ill.
Consolidated Wire & Associated Corps., 1635 S. Clinton St., Chicago 16, Ill.
Cornish Wire Co., 15 Park Row, New York, N. Y.
Crescent Co. Inc., Front & Central Ave., Pawtucket, R. I.
Crescent Insulated Wire & Cable Co., Trenton, N. J.
Diamond Wire & Cable Co., 128 East 16th St., Chicago Heights, Ill.
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Electric Auto-Lite Co., Toledo 1, Ohio
Electric Switch Corp., 14th at Union St., Columbus, Ind.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
Flexo Wire Co., 638 Genesee St., West Syracuse 1, N. Y.
General Cable Corp., 420 Lexington Ave., New York, N. Y.
General Cement Mfg. Co., 919 Taylor Ave., Rockland, Ill.
General Electric Co., Bridgeport, Conn.
General Insulated Wire Works, Inc., 69 Gordon Ave., Providence 5, R. I.
J. F. D. Mfg. Co., 4111 Ft. Hamilton Parkway, Brooklyn, N. Y.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Lenz Electric Mfg. Co., 1751 N. Western Ave., Chicago 47, Ill.
Lowell Insulated Wire Co., 171 Lincoln St., Lowell, Mass.
New England Electrical Wks., Inc., 365 Main St., Lisbon, N. H.
Packard Electric Div., General Motors Corp., Warren, Ohio
Paranite Wire & Cable Div. Essex Wire Corp., 1601 Wall St., Fort Wayne 6, Ind.
Phelps Dodge Copper Products Corp., American Copper Prods. Div., 40 Wall St., New York, N. Y.
Philmore Mfg. Co., 113 University Pl., New York, N. Y.
Plastic Wire & Cable Corp., Norwich, Conn.
Rhode Island Insulated Wire Co., Providence, R. I.
Rockbestos Products Corp., 308 Nicoll St., New Haven 4, Conn.
Roebling's Sons Co., John A., 640 Broad St., Trenton 2, N. J.
Rome Cable Corp., 330 Ridge St., Rome, N. Y.
Surprenant Electrical Insulation Co., 84 Purchase St., Boston 10, Mass.
United States Rubber Co., 1230 Sixth Ave., New York, N. Y.
Westinghouse Lamp Div., Westinghouse Electric Corp., Bloomfield, N. J.
Whitney-Blake Co., Dixwell Ave., New Haven, Conn.
Wood Electric Co., Inc., C. D., 826 Broadway, New York 3, N. Y.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

MAGNET WIRE

Alpha Wire Corp., 50 Howard St., New York, N. Y.
American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Ansonia Electrical Co., Ansonia, Conn.
Belden Mfg. Co., 4647 W. Van Buren St., Chicago 44, Ill.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Consolidated Wire & Associated Corps., 1635 S. Clinton St., Chicago 16, Ill.
Electric Auto-Lite Co., Toledo 1, Ohio
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Engineering Laboratories, Inc., 602 East Fourth St., Tulsa 3, Okla.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
General Cable Corp., 420 Lexington Ave., New York, N. Y.
General Electric Co., Bridgeport, Conn.
Goldmark Wire Co., James, 116 West St., New York 7, N. Y.
Guthman & Co., Edwin I., 15 S. Throop St., Chicago, Ill.
Hudson Wire Co., Winsted Div., Winsted, Conn.
Kellogg Switchboard & Supply Co., 6650 S. Cicero Ave., Chicago 38, Ill.
Knickerbocker Anunciator Co., 116 West St., New York, N. Y.
Lewyt Corp., 60 Broadway, Brooklyn, New York
Meissner Mfg. Div., Maguire Industries, Inc., Mt. Carmel, Ill.
New England Electrical Wks., Inc., 365 Main St., Lisbon, N. H.
Paranite Wire & Cable Corp., Div. Essex Wire Co., 1601 Wall St., Fort Wayne 6, Ind.
Phelps Dodge Copper Products Corp., American Copper Prods. Div., 40 Wall St., New York, N. Y.
Philadelphia Insulated Wire Co., 200 N. Third St., Philadelphia, Pa.
Rea Magnet Wire Co., Inc., E. Pontiac St., Extended Fort Wayne, Ind.
Rockbestos Products Corp., 308 Nicoll St., New Haven 4, Conn.
Roebling's Sons Co., John A., 640 S. Broad St., Trenton 2, N. J.
Rome Cable Corp., 330 Ridge St., Rome, N. Y.
Spencer Wire Co., West Brookfield, Mass.
Swedish Iron & Steel Corp., 17 Battery Place, New York, N. Y.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Wheeler Insulated Wire Co., Inc., 378 Washington Ave., Bridgeport, Conn.
Wickwire Spencer Metallurgical Corp., 260 Sherman St., Newark, N. J.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

POWER CORDS

Aircraft Products Co., 3502 E. Pontiac St., Fort Wayne, Ind.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
Alpha Wire Corp., 50 Howard St., New York, N. Y.
American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Ansonia Electrical Co., Ansonia, Conn.
Belden Mfg. Co., 4647 W. Van Buren St., Chicago 44, Ill.
Birnbach Radio Co. Inc., 145 Hudson St., New York, N. Y.
Boston Insulated Wire & Cable Co., 65 Bay St., Dorchester, Boston, Mass.
Clarostat Mfg. Co., Inc., 130 Clinton St., Brooklyn, N. Y.
Columbia Wire & Supply Co., 4106 N. Pulaski Rd., Chicago 41, Ill.
Consolidated Wire & Associated Corps., 1635 S. Clinton St., Chicago 16, Ill.
Cornish Wire Co., 15 Park Row, New York, N. Y.
Crescent Co., Inc., Front & Central Ave., Pawtucket, R. I.
Crescent Insulated Wire & Cable Co., N. Olden Ave., Trenton, N. J.
Diamond Wire & Cable Co., 128 East 16th St., Chicago Heights, Ill.
Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn.
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Electric Auto-Lite Co., Toledo 1, Ohio
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
General Cable Corp., 420 Lexington Ave., New York, N. Y.
General Electric Co., Bridgeport, Conn.
General Insulated Wire Works, Inc., 69 Gordon Ave., Providence 5, R. I.
Hazard Insulated Wire Works, Div. of The Okonite Co., Wilkes-Barre, Pa.
Insuline Corp. of America, 36-02 35th Ave., Long Island City, N. Y.
J. F. D. Mfg. Co., 4111 Fort Hamilton Parkway, Brooklyn, N. Y.
Kerite Insulated Wire & Cable Co., 30 Church St., New York 7, N. Y.
Lenz Electric Mfg. Co., 1751 N. Western Ave., Chicago 47, Ill.
Lowell Insulated Wire Co., 171 Lincoln St., Lowell, Mass.
National Electric Products Corp., Fulton Bldg., Pittsburgh, Pa.
Okonite Co., Canal St., Passaic, N. J.
Packard Electric Div., General Motors Corp., Warren, Ohio
Paranite Wire & Cable Div., Essex Wire Corp., 1601 Wall St., Fort Wayne 6, Ind.
Phelps Dodge Copper Products Corp., American Copper Products Div., 40 Wall St., New York, N. Y.
Philmore Mfg. Co., 113 University Place, New York, N. Y.
Roebling's Sons Co., John A., 640 S. Broad St., Trenton 2, N. J.
Rome Cable Corp., 330 Ridge St., Rome, N. Y.
Runzel Cord & Wire Co., 4731 W. Montrose Ave., Chicago, Ill.
Simplex Wire & Cable Corp., 79 Sidney St., Cambridge 39, Mass.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Western Insulated Wire, Inc., 1151 South Broadway, Los Angeles 15, Calif.
Whitney-Blake Co., Dixwell Ave., New Haven, Conn.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

RESISTANCE and FILAMENT WIRE

Allegheny Ludlum Steel Corp., Brackenridge, Pa.
Alloy Metal Wire Co., Prospect Park, Pa.
American Brass Co., Waterbury 88, Conn.
American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Callite Tungsten Corp., 544 39th St., Union City, N. J.
Chase Brass & Copper Co., Inc., 236 Grand St., Waterbury 91, Conn.
Cohn & Co., Sigmund, 44 Gold St., New York, N. Y.
Columbia Wire & Supply Co., 4106 N. Pulaski Road, Chicago 41, Ill.
Driver Co., Wilbur B., 150 Riverside Ave., Newark, N. J.
Driver-Harris Co., 201 Middlesex St., Harrison, N. J.
Electric Auto-Lite Co., Toledo 1, Ohio
General Electric Co., Bridgeport, Conn.
General Insulated Wire Works, Inc., 69 Gordon Ave., Providence 5, R. I.
Gibbs & Co., Thomas B., Div. of George W. Borg Corp., 814 Michigan St., Delavan, Wisc.
Goldmark Wire Co., James, 116 West St., New York 7, N. Y.
Haydu Bros., Mt. Bethel Rd., Plainfield, N. J.
Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.
J. F. D. Manufacturing Co., 4111 Fort Hamilton Pkway., Brooklyn, N. Y.
Jelliff Mfg. Corp., C. O., 200 Pequot Ave., Southport, Conn.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
North American Philips Co., 100 East 42nd St., New York 17, N. Y.
Northern Mfg. Co., Inc., 36 Spring St., Newark, N. J.
Precision Resistor Co., 334 Badger Ave., Newark 8, N. J.
Radio Corp. of America, Tube Div., RCA. Harrison, N. J.
Spencer Wire Co., West Brookfield, Mass.
Swedish Iron & Steel Corp., 17 Battery Place, New York, N. Y.
Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.
Westinghouse Electric Corp., East Pittsburgh, Pa.
Westinghouse Lamp Div., Westinghouse Electric Corp., Bloomfield, N. J.
Wickwire Spencer Metallurgical Corp., 260 Sherman St., Newark, N. J.
Wickwire Spencer Steel Co., 500 Fifth Ave., New York, N. Y.

SHIELDED WIRE

Acorn Insulated Wire Co., Inc., 225 King St., Brooklyn 31, N. Y.
Air Shields, Inc., Hatboro, Pa.
Alden Products Co., 117 North Main St., Brockton 64, Mass.
Alpha Wire Corp., 50 Howard St., New York, N. Y.
American Steel & Wire Co., Rockefeller Bldg., Cleveland 13, Ohio
Anaconda Wire & Cable Co., 25 Broadway, New York 4, N. Y.
Ansonia Electrical Co., Ansonia, Conn.
Belden Mfg. Co., 4647 W. Van Buren St., Chicago 44, Ill.
Birnbach Radio Co., Inc., 145 Hudson St., New York, N. Y.
Boston Insulated Wire & Cable Co., 65 Bay St. (Dorchester), Boston, Mass.

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Connecticut Cable Corp., Jewett City, Conn.
Cornish Wire Co., Inc., 15 Park Row, New York, N. Y.
Crescent Insulated Wire & Cable Co., N. Olden Ave., Trenton, N. J.
Diamond Wire & Cable Co., 128 E. 16th St., Chicago Heights, Ill.
Electric Auto-Lite Co., Wire & Cable Div., Port Huron, Mich.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
Fishwick Radio Co., 430 Colorado Bldg., Washington, D. C.
Flexo Wire Co., 638 Genesee St., W., Syracuse 1, N. Y.
General Cable Corp., 420 Lexington Ave., New York, N. Y.
General Electric Co., Bridgeport, Conn.
General Insulated Wire Works, Inc., 69 Gordon Ave., Providence 5, R. I.
Goldmark Wire Co., James, 116 West St., New York 7, N. Y.
J. F. D. Mfg. Co., 4111 Fort Hamilton Pkway., Brooklyn, N. Y.
Johnson Co., E. F., Waseca, Minn.
Lenz Electric Mfg. Co., 1751 N. Western Ave., Chicago 47, Ill.
Lewis Engineering Co., 52 Rubber Ave., Naugatuck, Conn.
Nonotuck Manufacturing Co., Holyoke, Mass.
Packard Electric Div., General Motors Corp., Warren, Ohio
Plastic Wire & Cable Corp., Norwich, Conn.
Precision Tube Co., 3828 Terrace St., Philadelphia 28, Pa.
Rockbestos Products Corp., 308 Nicoll St., New Haven 4, Conn.
Roebling's Sons Co., John A., 640 Broad St., Trenton 2, N. J.
Simplex Wire & Cable Co., 79 Sidney St., Cambridge 39, Mass.
Suprenant Electrical Insulation Co., 84 Purchase St., Boston 10, Mass.
Uniform Tubes, Shurs Lane & Lauriston St., Roxborough, Philadelphia, Pa.
United States Rubber Co., 1230 Sixth Ave., New York 20, N. Y.
Western Insulated Wire, Inc., 1151 South Broadway, Los Angeles 15, Calif.
Whitney-Blake Co., Dixwell Ave., New Haven, Conn.
York Wire & Cable Div., General Electric Co., Bridgeport, Conn.

X-ray Tubes & Equipment

see Tubes

COPIES OF THIS DIRECTORY AVAILABLE ON REQUEST

The editorial staff of ELECTRONICS, realizing the importance and timeliness of this Buyers' Guide, is again planning a limited number of reprints. This procedure has been followed for some years in order to provide all members of the engineering, production and maintenance departments, with complete and last minute reports on all reliable sources for electronic components as well as complete equipment.

This year, in view of resumed civilian and industrial production, this information is of vital importance. Copies are bound in convenient fashion and are available at .....

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EDITORIAL DEPARTMENT, ELECTRONICS,
330 West 42nd Street, New York 18, N. Y.

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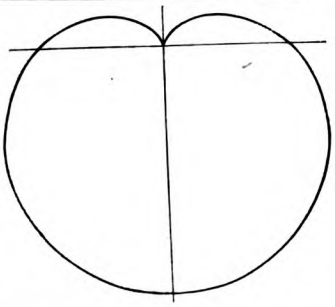
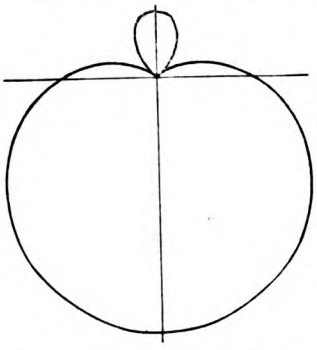
. . This is Cardioid

"Cardioid" means heart-shaped. It describes the pickup pattern of a microphone as illustrated in this diagram. Unwanted sounds approaching from the rear are cancelled out and the pickup of random noise energy is reduced by 66%. The actual front to back ratio of reproduction of random sound energy is 7 to 1.



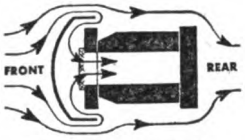
. . This is Super-Cardioid

"Super-Cardioid" also describes a pickup pattern and is a further improvement in directional microphones. The Super-Cardioid has a wide front-side pickup angle with greater exclusion of sounds arriving from the sides and the rear. The front to back random sound ratio is 14 to 1 which makes it twice as unidirectional as the "Cardioid." A 73% decrease in the pickup of random noise energy is accomplished.

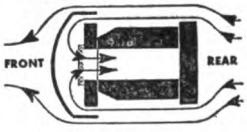


. . This is Uniphase

"Uniphase" describes the principle by which directional pickup is accomplished in a single Microphone unit. This is a patented Shure development and makes possible a single unit "Super-Cardioid" Directional Microphone eliminating the necessity of employing two microphone units in one case—it gives greater uniformity in production, greater ruggedness, lower cost for comparable quality and more uniform vertical pickup pattern.



Sounds entering from front.



Sounds entering from rear.

. . This is the result

The SHURE Super-Cardioid

A decrease in the pickup of random sound energy by 73%—reduction of feedback and background noise—simplification of sound pickup are among the many advantages offered by the Shure "Super-Cardioid" Dynamic. These, plus faithful reproduction, are the reasons why Shure "Super-Cardioid" Microphones are used by more than 750 Broadcast Stations in the United States alone, by our Armed Forces throughout the world, and on thousands of Public Address Systems everywhere.

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NEW PRODUCTS

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Features of Stroboscopic Light Source

FOR INSPECTION, stress study and timing of reciprocating and rotating motion and electron switch and relay applications, Sylvania Electric Products Inc., of Salem, Mass., now has available cold-cathode electron tubes with two internal trigger grids for operation in simple capacitor discharge circuits. Used as a source of stroboscopic light, these strobotron tubes provide pulse frequencies up to 240 pulses per second. Standard strobotrons measure 4½ in. overall, including a T-9 bulb and a 4-pin base, 1⅞ in. in diameter. Fifty milliamperes average current with 350-v d-c on the anode permits instantaneous surges of 5 amp. Grids are operated at 70-v d-c and 15 ma maximum. There is a drop of 75 volts during glow discharge and a 20-v drop during arc discharge. Starting is initiated by discharge between any two elements but usually between grids or either grid and cathode. Starting voltages range between 70 and 145-v d-c depending on the elements used in their polarity.

Applications of the strobotrons include continuous visual inspection of moving textiles and printing from high-speed rotary presses; precise timing of cams, shafts, flywheels, gears, pulleys, fan blades, spindles and shuttles, and many other rotating or reciprocating parts. The tubes also make visual study of stress or effect (during operation, in actual service) easy by creating stop, reverse or slow motion which may be photographed for reference or permanent record. Frequency of flashing may be readily controlled and calibrated over wide limits to produce a compact direct-reading instrument. High available peak currents make these tubes particularly adaptable to relay and control applications because they are fully enclosed and without moving parts and because they provide positive and powerful relay action in applications where other types of relays may fail or produce operating hazards in corrosive or explosive atmospheres.

Stroboscopic light played a large part in the exact balancing of rotating parts in the Norden bombsight where tolerances were kept within 20 millionths of an inch. Timed light flashes permitted precise determination of rotating speeds and visual study of imbalance during laboratory tests. In the photograph (bottom) light flashes were produced by a strobotron tube manufactured by Sylvania Electric. The technician is making production tests of bombsight equipment in the laboratory of the Victor Adding Machine Company, using a General Radio Strobotac and a Gisholt Dynetric Balancer.

Folded Unipole Antennas

THESE FOLDED UNIPOLE antennas weigh 15 lb and are for use in transmitting and receiving at frequencies from 30 to 40 mc and for powers up to 5,000 w. Antennas for higher frequencies are being designed by the manufacturer, Andrew Co., 363 East 75th St., Chicago 19, Ill. Features of the units are as follows: Lightning hazard is minimized by grounded vertical element; "slide trombone" calibration permits exact adjustment for

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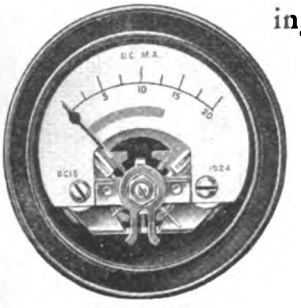
Anyway you look at them...

THEY'RE GREAT LITTLE METERS!

Side View

Front, side or back—inside and out—the 1½" Round Model 120 can do a whale of a job for you on a wide variety of applications.

External pivots provide maximum accuracy in mounting the moving element between the jewel bearings ...prevent rocking of pointer...reduce side friction between jewels and pivots...increase the life of bearing surfaces. Movements are designed to meet forthcoming JAN-I-6 specifications for 1½ inch instruments.

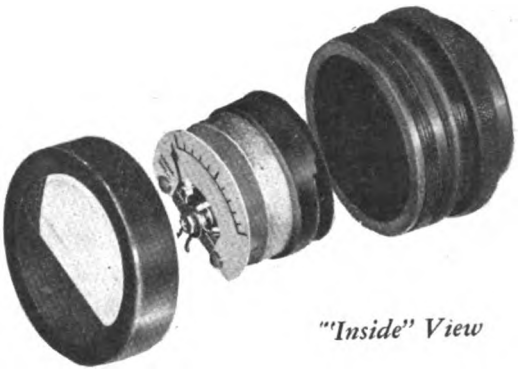


Front View

Built with fine precision, entirely self-contained ...with built-in resistors and shunts, this great little meter is also completely immersion-proof throughout. It has a special locking device for exerting pressure against rubber gaskets on either side of the glass. Watertight sealing includes terminal studs and a gasket back of the flange waterproofs the juncture between the meter and the panel. Installation is easy—a ring mounting eliminates mounting screws. The case is Black Anodized Aluminum.

Back View

Model 112 has all the features of the Model 120 except that it has a square, bakelite case. Like the 120 it is available either as a D.C. or A.C. (rectifier) instrument. Write for latest catalog.



"Inside" View

WAR BONDS

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GENERAL OFFICE: NORTHERN BLVD. AT 45th STREET, LONG ISLAND CITY 1, N. Y.

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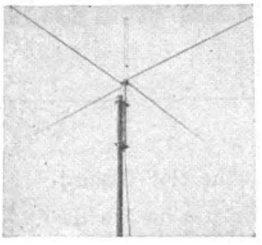
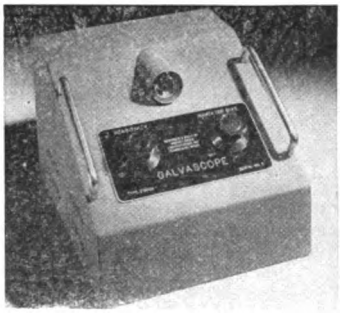
any frequency between 30 and 40 mc; a non-reactive impedance with a resistive component varying between 62 and 75 ohms is provided; when the antenna is used with transmitters there is no standing wave on the line, thus reducing line losses and voltage flashover, and freedom from reflections is obtained; the band-width is good for f-m because it is not less than 400-kc wide for a standing wave ratio of 1.2 to 1, and by careful selection of transmission-line impedance, may be made as wide as 1 mc; the antenna may be used with any 70-ohm coaxial cable, solid dielectric or beaded, up to ½-in diameter.



An Electronic A-C Galvanometer for Commercial Use

HARVEY LABORATORIES, Inc., 447 Concord Ave., Cambridge, Mass., has announced for commercial use their Galvascope, essentially an electronic a-c galvanometer which provides a visual means for detecting bridge balance. Since the instrument employs a 6E5 tube as an indicator and has no moving parts whatsoever, electrical overload and mechanical shock cannot injure it, and there is no waiting for an undamped galvanometer needle to come to rest. Difficulties sometimes encountered with vibration-type galvanometers have been eliminated from this instrument. The Galvascope is housed in a welded-steel cabinet with two operating controls (sensitivity and indicator bias) on a sloping panel. Side louvres and rear openings provide adequate ventilation and hold the temperature rise to a maximum of 30 C. All tubes except the indicator tube are conveniently mounted in a tube compartment which is easily accessible. Two permanently attached cords provide connections to a 115-v, 50-60 cycle a-c line and to the detector terminals of any 1000-cycle a-c bridge. The signal cord terminates in a specially designed banana-type plug having standard ¾-in. spacing between terminals.

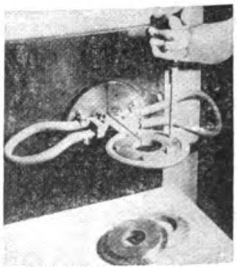
In designing the circuit of the instrument, use of the optical advantage of working with a small angular opening of the indicator tube eye is utilized. The circuit consists of an a-c amplifier, a signal rectifier, an indicator, and a self-contained power supply. The operation of the device involves amplification of the 1000-cycle bridge signal, followed by rectification of the amplified signal and application of the indicator tube. In the absence of signal, the eye of the indicator tube is closed or overlapped, depending upon the setting of the indicator bias control. When signal voltage is applied, the eye opens. As the bridge is brought into balance the signal decreases, and is indicated by closing of the eye. By proper manipulation of the controls, the eye is just closed (but not overlapped) at balance, whereas slightly off balance the eye is open to a small angle. The manufacturer states that the term balance as used here is intended to mean the nearest approach to a complete null, and may represent a minimum signal of some magnitude. In other words, two major accomplishments are achieved: detection of a very small signal, and detection of a very small change in a relatively large signal.



The problem of reflected light is solved by the horizontal mounting of the tube, and an adjustable shield is incorporated in the instrument to solve the problem of stray light. Tubes, resistors and capacitors are operated at no more than two-thirds maximum rating, and in most cases the safety factor is considerably greater.

Master Coil Sets for Electronic Heating

THE INDUCTION HEATING Corporation (389 Lafayette St., New York 3, N. Y.) has developed master coil sets for users of Thermionic electronic heating equipment to aid them in immediately adapting the unit to any specific application in a minimum of time. The sets consist of master coils and removable inserts in diameter sizes ranging from ½ in. to 3 in., and of any desired thicknesses so that the coils are capable of heating axial bands of various widths to produce many heat patterns. Blank inserts are available to allow the user to cut the desired contour to match a particular work. Inserts can be changed in a matter of seconds since they



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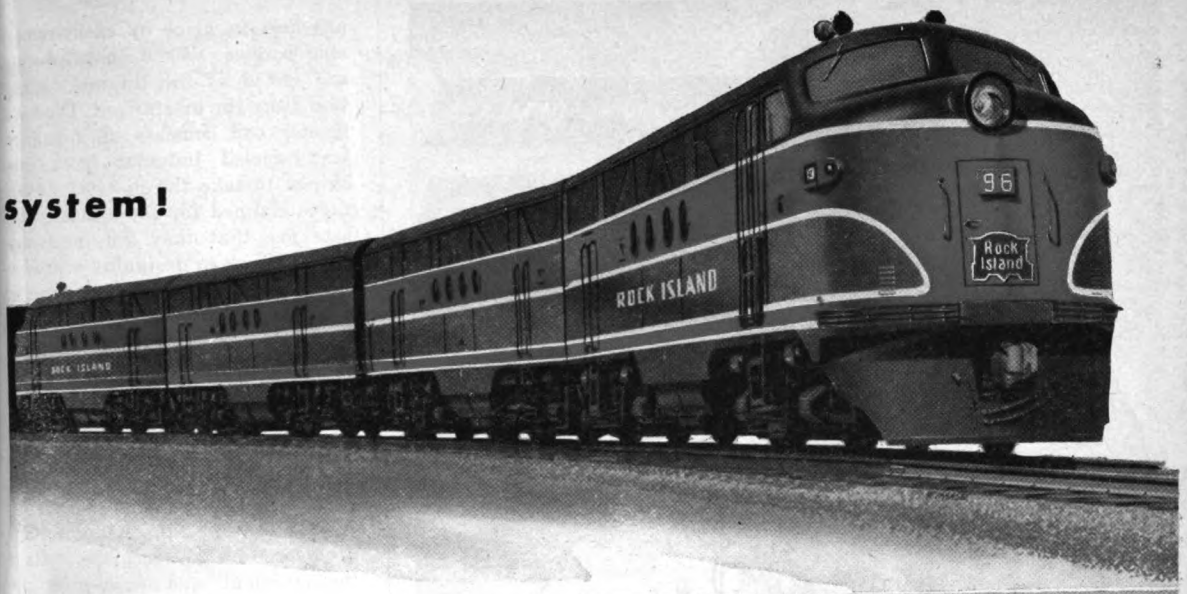
system!



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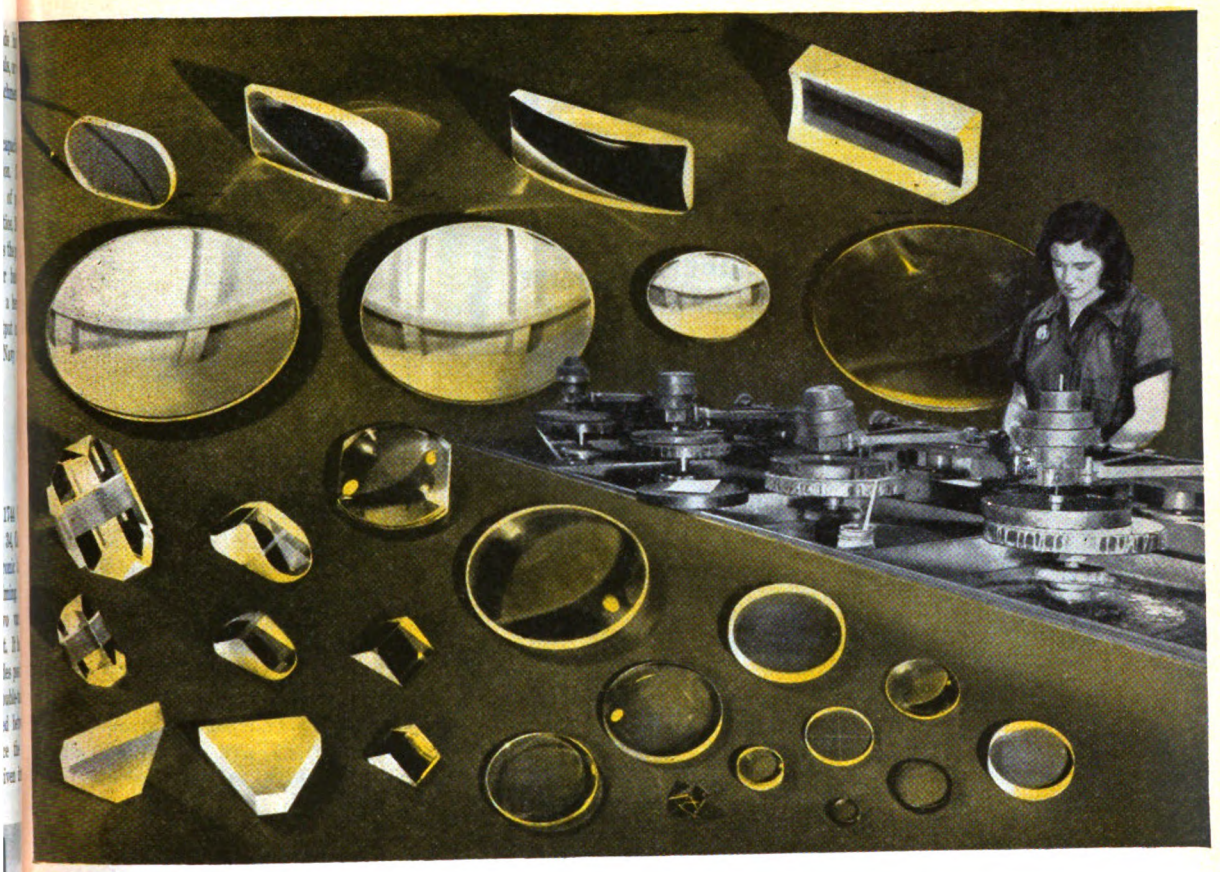

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Our compact group of trained technicians is ready to go to work for a few additional manufacturers. But, as reconversion progresses, our plant becomes increasingly busy. Those who need optics should readily see the wisdom of making their requirements known to us at an early date so that we can give them the prompt service demanded by these times.

A new booklet, "Precision Optics by American Methods," tells how our company has developed optical manufacturing techniques, why we continue to concentrate all our efforts on the production of precision optics for others, and how we can be of exceptional service to those who need optical components. We shall be pleased to send you a copy of this new booklet on request.

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Write for descriptive technical Bulletin 8

BALLANTINE LABORATORIES, INC

BOONTON, NEW JERSEY, U. S. A.

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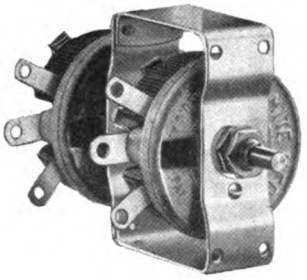
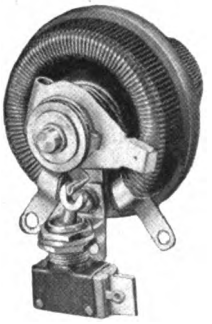


Rheostat Tandem Assembly



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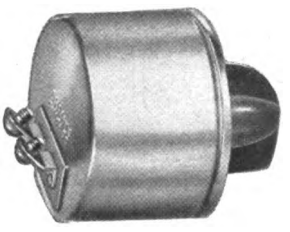

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Full Range

HIGH AND LOW FREQUENCY REPRODUCTION IN ONE ASSEMBLY!

HORIZONTAL SOUND DISTRIBUTION 80°

TRU-SONIC

CO-AXIAL SPEAKER

The Tru-Sonic Co-Axial Speaker combines a high frequency metal diaphragm reproducer and a low frequency paper cone reproducer, mounted together with the dividing network in a single, compact assembly, 15" in diameter and 9" in depth giving a horizontal sound distribution of 80 degrees. Outstanding for custom quality, and excellence before the war, the Tru-Sonic Speaker is finer than ever, but is available at a lower price, because of quantity production. Available now! Write for illustrated brochure.

Licensed under Western Electric Patents

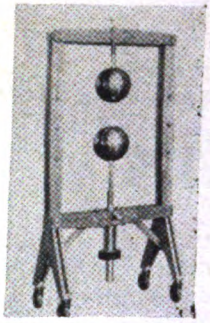
STEPHENS MANUFACTURING CO.

10416 NATIONAL BLVD.

LOS ANGELES 34, CALIF.

Sphere Gaps for High-Voltage Measurements

A COMPLETE LINE of sphere gaps, for accurate measurement of high voltages used in a-c or d-c testing, has been announced by General Electric's Transformer Division, Pittsfield, Mass. Available in standard diameters of 2, 6.25, 12.5, 25, 50, 75, and 100 cm for spark-over voltage ranges of 8.5-45 to 261-1338-kv crest, the sphere gaps are furnished complete with current-limiting series resistance assemblies. The units provide a direct and accurate method of gaging test voltages; serve as protective devices to prevent overvoltage on the test specimen or apparatus during high-potential testing; indicate



crest voltage regardless of wave form; are relatively unaffected by humidity changes in the air; have practically no time lag; and provide consistent spark-over voltages.

The 2- and 6.25-cm gaps are both table-type, with electrodes mounted horizontally in wooden supports. The larger sizes are floor types with highly polished spheres mounted vertically in a rectangular frame. All of the sphere gaps are provided with precision adjustments for gap spacing. Sphere gaps of 25 cm and larger can be provided with casters for easy mobility, and a motor drive for gap adjustment if desired.

The current-limiting resistance assemblies are made of non-inductive, wire-wound rods mounted on treated wooden frames.

Receiver-Transmitter Unit

AIRADIO, INC. (Stamford, Conn.) announced final production plans for a receiver-transmitter unit weighing only 10.6 lb, for private air-

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P

FAB

EXA

For name any other consult Sil is particula mand fabri experienced four ways:

1. *In wor*
2. *In dev*
3. *In adv tical fabrica*
4. *In sele your re*

Remember, i more for Sil

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THE SIL

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Specialists in Made Plastics Technical and

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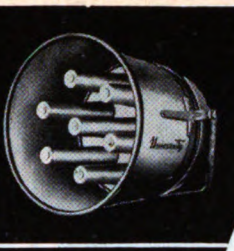
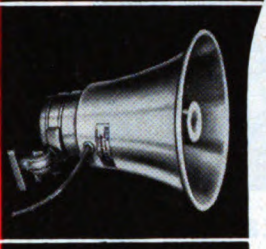
Models AA7, 4A4 and 2YR —MULTI-UNIT LOUDSPEAKERS: High powered directional units with power capacities from 50 to 250 watts and projection ranges from ¾ mile to 2 miles. AA7 illustrated.

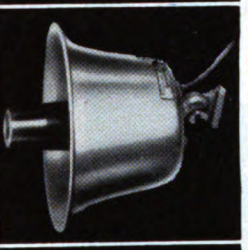


Models 1B8 and 1BR—PAGING AND INTER-COMMUNICATION SPEAKERS: Two high efficiency speakers of extreme applicability. 1B8 is directional. 1BR is a radial projector. 1B8 illustrated.



Models LH, PH and SMH—REFLEX HORNS: Rugged sound projectors capable of ½ mile directional coverage. Each unit features different frequency cutoff. LH illustrated.

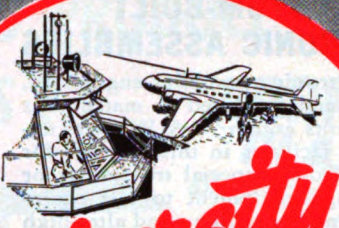
Models RCR and CR—HIGH EFFICIENCY BOOSTER SPEAKERS: These hermetically sealed units are designed to over-ride high noise levels in indoor or outdoor locations—docks, shipping rooms, loading platforms. RCR is radial type; CR directional. CR illustrated.



Models RLH, RPH and RSH —RADIAL LOUDSPEAKERS: These units provide 360° coverage with three choices of low frequency cutoff. They are designed for minimum sount concentration beneath the speaker. RPH illustrated.

PAH and SAH—DRIVER UNITS: UNIVERSITY Driver units incorporate such special features as rim centering, all-weather construction —that increase efficiency and make possible a breakdown-proof guarantee. Designed to fit any UNIVERSITY PROJECTOR.

Models RBP12 and RBP8—RADIAL CONE SPEAKERS PROJECTORS: Radial, cone speaker projectors incorporating infinite baffle design for excellent low frequency response. RBP12 illustrated, takes 12" cone speaker; RBP8 takes 8" cone speaker.



University Speakers

..for every installation!

Backed by a record of leadership in the pioneering of the reflex, non-resonant, horn-type projectors, and high power, weather-proof breakdown proof driver units, the all-inclusive line of UNIVERSITY speakers represents the most diversified in the field.

As a result of the long, specialized experience, it is now possible to specify a UNIVERSITY unit exactly suited to any particular requirement. Both indoor and outdoor types are available for high fidelity reproduction, or with characteristics suitable for crisp clarity, and capable of over-riding high surrounding noise levels.

Each UNIVERSITY speaker incorporates special features—both electrical and mechanical—which assure maximum efficiency and dependable functioning at all times.

SPECIAL FEATURES

"U" BRACKET MOUNTING: This feature reduces mounting to a simple straightforward procedure and permits orientation of the projectors with the ease of spotting a searchlight.

RIM DAMPING: All UNIVERSITY speakers and projectors are rubber rim loaded to eliminate mechanical and acoustic resonance. All traces of rattle and reverberation are eliminated even at full power output.

ALL WEATHER CONSTRUCTION: Climate and exposure can not impair the fine performance of UNIVERSITY loudspeakers. Heavy gauge metal construction, complete enclosure of the driver units, dust and water proof design recommends them for any installation indoor, outdoor or shipboard.

UNIVERSITY LABORATORIES

225 VARICK STREET
NEW YORK, 14, N.Y.

University

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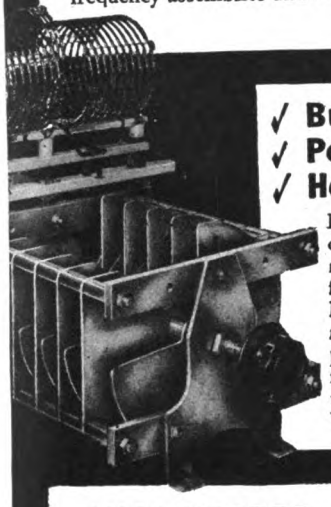
CUSTOM-BUILT ELECTRONIC ASSEMBLIES

Need electronic assemblies engineered, designed and produced to match your requirements *exactly?* B & W offers unsurpassed facilities in this respect—for anything from a special transmitter or high-voltage equipment to test equipment, tuning units, high—and ultra-high frequency assemblies and dozens of others.



✓ **Built-in Neutralization**
✓ **Perfect Design Symmetry**
✓ **Heavy-Duty Construction**

Half the length of conventional dual units, designed for built-in neutralization, and thus having perfect design symmetry, B & W Heavy-Duty Variable Condensers assure a remarkable improvement in the performance of any equipment from a transmitter to a dielectric heating assembly. Write for Bulletin 75-C.

CYCLOMETER COUNTERS

Count shaft rotations—facilitate making pre-determined settings

B & W Cyclometer Counter assemblies are useful wherever a shaft must be turned a pre-determined number of times, or set at any exact pre-determined position. Exact settings to tenths of a turn are automatically recorded. Write for Cyclometer Bulletin.

B&W

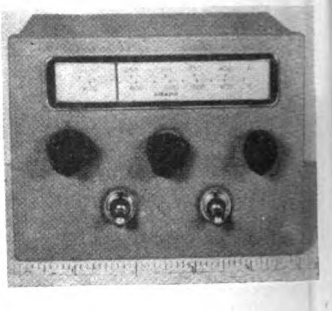
ARMY E NAVY

BARKER & WILLIAMSON

DEPT.E-115, 235 FAIRFIELD AVE., UPPER DARBY, PA.

Export: LINDETEVES, INC., 10 Rockefeller Plaza, New York, N.Y., U.S.A.

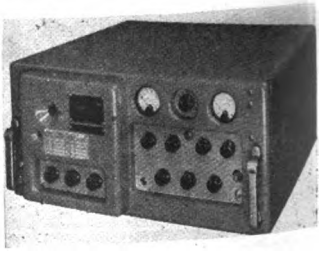
craft. This communications system is compact, highly sensitive, and ruggedly constructed. It provides standard plane-to-ground communication, radio range, weather broad-



cast, and standard broadcast reception, as well as interphone communication between pilot and passengers. A radio range filter is incorporated into the receiver. The range signal can be eliminated by merely flicking a toggle switch (located in the front panel of the receiver) to permit reception of voice only.

Newly Designed Radio Receiver

TO PROVIDE EASIER accessibility of parts for servicing and maintenance of radio receivers, the National Radio Company of Malden, Mass., has completely redesigned its radio receivers. Lock handles, shown in the accompanying illustration at either side of the set, immediately release (by the flick of



the wrist) the panel section from the cabinet. Design of the interior mechanism utilizes a drawer slide which does away with the necessity of removing the receiver from the cabinet. With the receiver pulled out on this drawer slide, the

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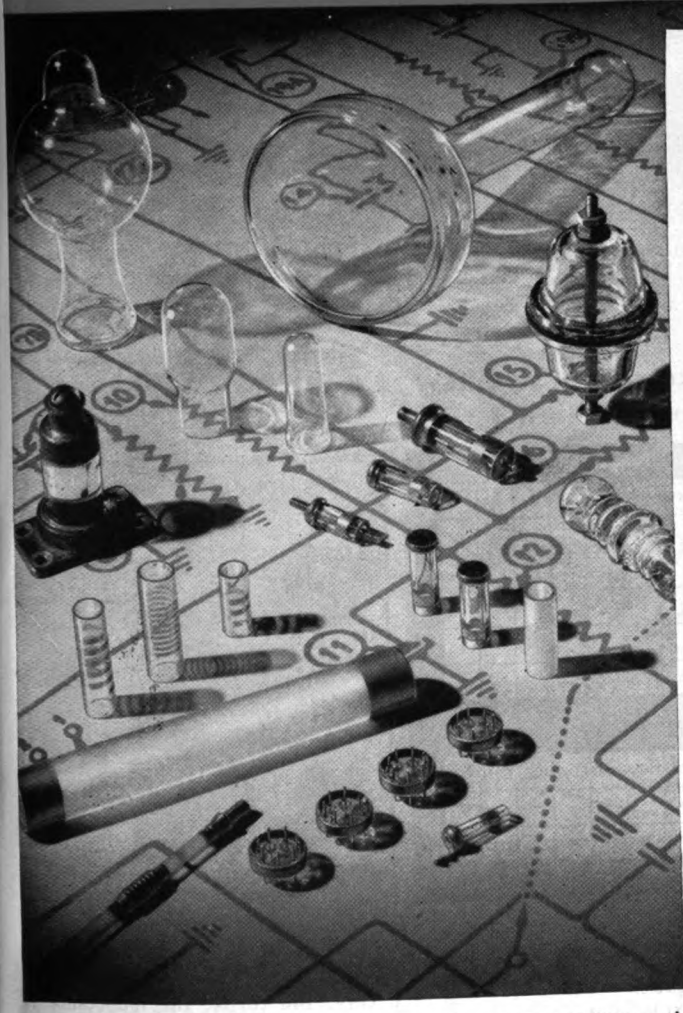
CORNING GLASS GIVES YOU



Special Electrical Qualities
Thermal Endurance
Hermetic Sealing
Mechanical Strength
Corrosion Resistance
Precision
Permanence
Metallizing
Dimensional Stability

High dielectric strength — high resistivity—low power factor—wide range of dielectric constants—low losses at all frequencies.

Permanent hermetic seals against gas, oil and water readily made between glass and metal or glass and glass.

Commercial fabrication to the fine tolerances of precision metal working.

Corning's metallizing process produces metal areas of fixed and exact specification, permanently bonded to glass.

AS YOU plan post-war electronic products, give a thought to versatile glass. We really mean glasses, for Corning has, at its fingertips, 25,000 different glass formulae from which to select those especially suited to your electronic applications. Let us show what glass can do for you. We may already have a solution — or Corning Research can find the answer for you. Phone Corning 2852 or wire Electronic Sales Dept., E-11, Bulb and Tubing Division, Corning Glass Works, Corning, New York. We'll have a man on the job promptly.

CORNING *means* Research in Glass

Electronic Glassware

VYCOR T.M.REG. CORNING T.M.REG. PYREX

"PYREX", "VYCOR" and "CORNING" are registered trade-marks and indicate manufacture by Corning Glass Works, Corning, N. Y.

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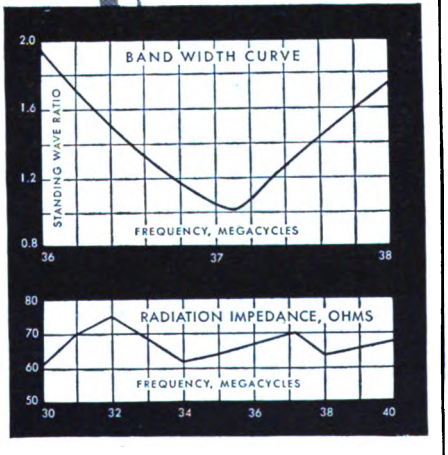
New FOLDED UNIPOLE ANTENNA

Another Example of ANDREW Ingenuity in Engineering

Concentrating on *electrical performance*, Andrew engineers have designed a unique Folded Unipole Antenna which—according to comparative tests—*easily outperforms other antennas at several times the price.*

Used for transmitting and receiving at frequencies from 30 to 40 MC and for powers up to 5,000 watts, this antenna has proved so successful that similar models for higher frequencies are now being designed.



FEATURES:

- Light weight — only 15 pounds — simplifies installation.
- Lightning hazard minimized by grounded vertical element.
- "Slide trombone" calibration permits exact adjustment for any frequency between 30 and 40 MC, using only a wrench. Optimum performance for that frequency is guaranteed without "cut and try" methods.
- Proper termination of coaxial transmission line. Unlike other "70-ohm" antennas, the Folded Unipole actually provides a non-reactive impedance with a resistive component varying between 62 and 75 ohms (see lower curve).
- Excellent band width, ideal for FM (see upper curve).

Andrew Co. specializes in the solution of antenna problems. For designing, engineering and building of antenna equipment, consult Andrew Co.

ANDREW CO.
363 EAST 75th ST., CHICAGO 19, ILL.

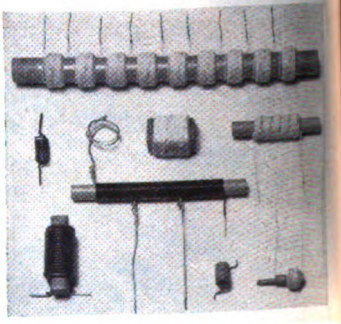
ANDREW

WRITE FOR FULL INFORMATION

set can be tilted into three different positions so that all components can be reached easily. The manufacturer states that the mechanical features could be readily adapted to commercial models, including wall-flush home sets. The new type receiver will be installed aboard fleet units and at shore stations.

Coils

THE BITTERMANN Electric Co., 50 Henry St., Brooklyn, N. Y. uses a bank-winding process to produce in quantity coils of high inductance and low distributed capacity and for radar receivers. In the accompanying illustration, the upper coil is No. 24 DCE wound on $\frac{1}{2} \times \frac{5}{8} \times 8$-in. Phenolite XXR tubing, each pie having 46 turns and an inductance value of 38 μh, with a total of 380 μh for the 9 pies and a distributed capacitance of 2.8 $\mu\mu$f at a frequency of 24 mc. Bank-wound coils are also made with iron-dust cores or square tubing to be used in



conjunction with Hipersil cores. The small coil (lower right) is No. 32 SCE wound on $\frac{1}{4}$ in. iron dust core, 146 turns; the inductance is 690 μh with a Q of 92 at 150 kc, with an impedance of over 2,200 ohms at 30 mc. Winding is $\frac{1}{8}$ in. diameter by $\frac{1}{8}$ in. long. Another type of coil produced is one wound with taps without cutting the wire or leaving space between the windings. The method used here is to bring the wire up in tight loops, retaining full size and continuing the winding of the coil. The insulation is stripped and No. 18 stranded tinned leads are soldered to the loops. Wire sizes used are from 20 enameled to 14 single glass covered.

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ADVANTAGES OF THERMOPLASTIC

There are fourteen practical advantages of theremoplastic insulation over older types of construction . . . advantages which PLASTIC engineering now makes possible at what, in most cases, is NO PRICE PREMIUM. Check them yourself: 1. Superior aging properties, 2. High resistance to oxidation, 3. Low moisture absorption, 4. High dielectric strength, 5. High tensile strength, 6. Resistance to flame, 7. Flexibility at low temperatures, 8. Resistance to abrasion, 9. Resistance to chemicals, 10. Resistance to oils and greases, 11. Ease of installation, 12. Increased capacity, 13. Attractive appearance, 14. Broad color range. Remember . . . when you're thinking of PLASTIC you're thinking of US!

Thermoplastic insulation specialists . . . producing a complete line from fine wires to heavy power cables . . . serving: Public Utilities, Radio, Electronic, Appliance and Instrument Manufacturers, Telephone Companies and Contractors.

PLASTIC

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..tagged for the big jobs!

HEXACON ELECTRIC SOLDERING IRONS

SPERRY

Douglas Aircraft

KAISER

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Westinghouse

TYPE P-150
This production iron provides a large reserve of heat at the right temperature for sustained production.

Follow the leaders — and you'll use HEXACON! For rugged, heavy duty work or for light, intricate work... for continuous production or hard-to-get at work... here's the answer. One reason is "Balanced Heat" — dissipating excessive element-imparing heat — and minimizing elemen burn-outs and tip replacements. Another, is their light weight, efficiency and dependability.

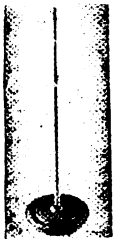
LITERATURE AVAILABLE—The complete HEXACON line of screw tip and plug tip irons from 40 to 700 watts, and with tip diameters ranging from ¼" to 1¾", is fully illustrated and described. Write today; no obligation.

HEXACON ELECTRIC CO.
130 W. CLAY AVENUE, ROSELLE PARK, N. J.

HEXACON
HIGH-QUALITY, LONG-LASTING SOLDERING IRONS

Microphone Floor Stand

TYPE A-63 MICROPHONE floor stand is being produced by Universal Microphone Co., Inglewood, Calif. for use with any microphone that has a ⅝-27 thread. The unit uses three upright sections. It comes supplied with knurled adjustment collars, is satin chrome plated, and its base



is of cast iron with black wrinkle finish. Range of the adjustable height is from 26 to 64 in. It can be used as a table or floor stand. The base weighs 7 lb; total shipping weight is 10 lb. Base and stand are packaged separately. The unit is priced at $12.50.

Silicone Varnish

DC-993 SILICONE insulation for higher operating temperatures or extremely severe service conditions was announced in the literature column of June ELECTRONICS, and now Dow Corning Corporation (Midland, Mich.) announces type DC-996 insulation which cures at 300 F. DC-996 is a new heat-stable, waterproof varnish for impregnating electrical equipment to obtain good thermal stability, protection against failure due to sustained overloads, higher operating temperatures, and protection against excessive moisture even after prolonged exposure to elevated temperatures. Another advantage claimed for this new silicone varnish is that electrical equipment can be baked fully assembled without damaging the commutators or the slip rings. The temperature required to cure DC-996 does not affect shellac-bonded mica or core plating. Characteristics of the varnish are as follows: Electrical properties (measured on coated panels at 25 C and 50 percent relative humidity) dielectric strength, volts per mil

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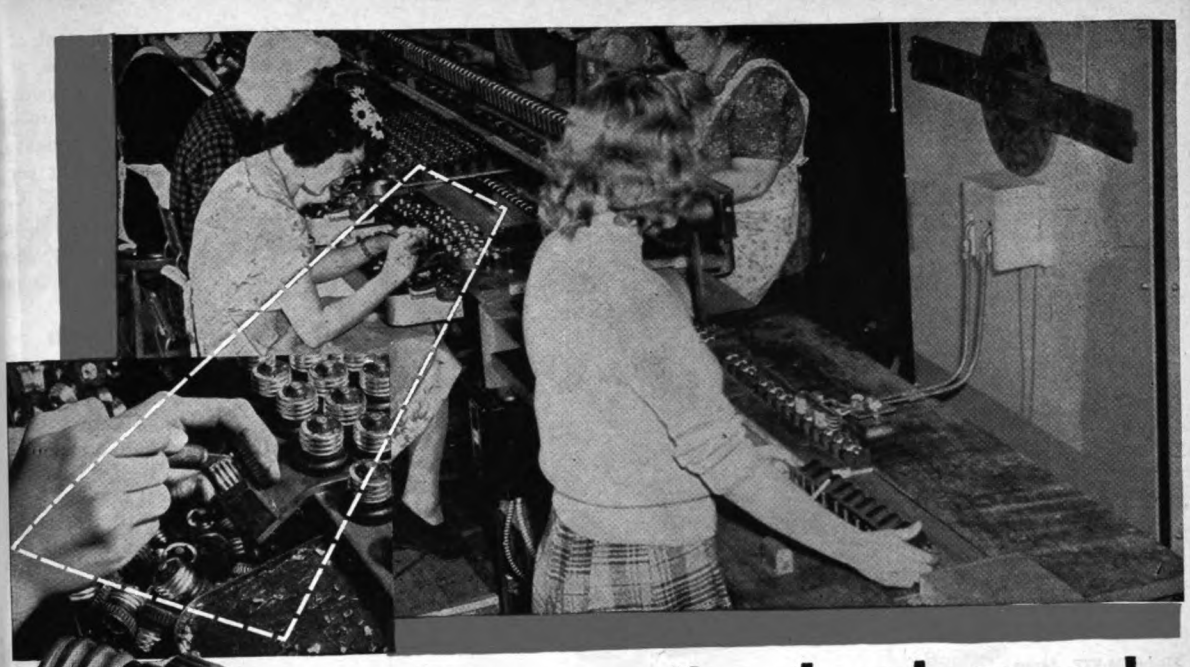
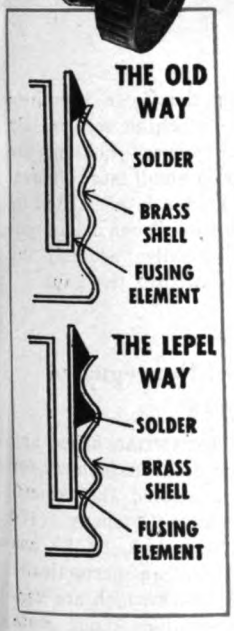


How "Economy" makes better plug fuses faster with Lepel Induction Heating



When the progressive management of Economy Fuse & Manufacturing Company wanted to improve the quality of its plug fuses, it was natural to turn to Lepel High Frequency Induction Heating, the modern metal joining method that is contributing so much to product improvement and production efficiency.

Formerly, the zinc fusing element was laboriously soldered to the brass screw shell by hand. This produced a shallow edge union and worker efficiency was impaired by heat and fumes from the battery of soldering irons.

Today, the fuse assemblies with solder wedges manually "tucked in" between fusing element and screw shell are placed in a jig (solder facing upward) and conveyed through the area of a high frequency work coil operated from a Lepel Unit. The solder melts instantly and, with the assembly tilted slightly, flows by gravity, completely filling the element channel and establishing a firm, recessed bond between the parts that insures utmost dependability.

Soldering is performed so fast that twelve girls are kept busy "tucking in" solder wedges.

This is one of scores of metal joining jobs Lepel Induction Heating is doing faster, better, more economically with soldering and brazing alloys of any melting point.

Metals of any analysis — ferrous or non-ferrous—and in any form, can be joined quickly by the controlled, measured heat generated by the Lepel Unit, producing quality results never before obtained by other metal joining methods.

By assembling parts with joint surfaces pre-fluxed and solder or brazing alloy pre-placed, it is possible to produce parts heretofore considered impractical to make by metal joining.

The simple, compact, dependable Lepel Unit requires no special operating skill and can also be used without alteration for localized hardening, annealing, stress relieving or melting.

If you have a metal joining or heat treating problem, a Lepel field engineer will be glad to study it and offer suggestions for solving it by this modern heating method. Just write

Lepel
High Frequency
INDUCTION HEATING UNITS

LEPEL HIGH FREQUENCY LABORATORIES, INC.

PIONEERS IN INDUCTION HEATING

***General Offices:* 39 West 60th Street, New York 23, N. Y.**

Lepel Units are now available without priority

DO IT FASTER, BETTER, MORE ECONOMICALLY BY LEPEL INDUCTION HEATING

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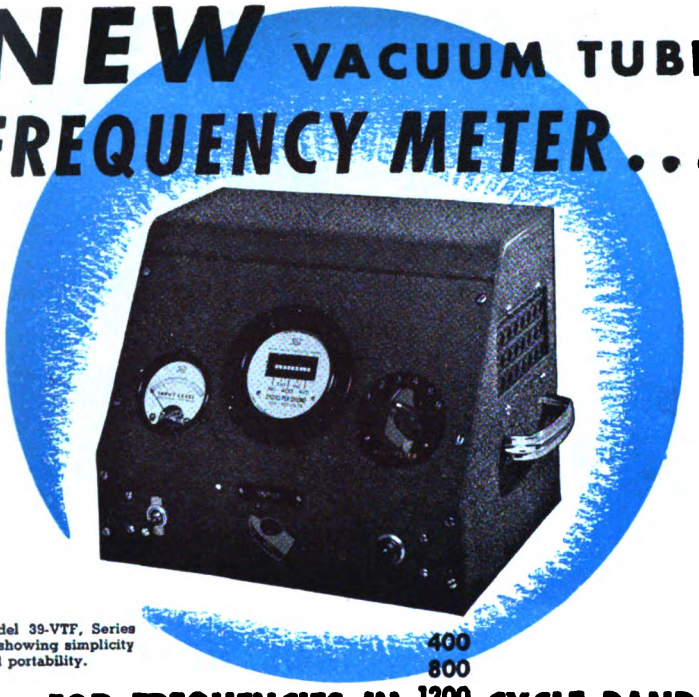
NEW VACUUM TUBE FREQUENCY METER . . .



Model 39-VTF, Series A, showing simplicity and portability.

. . . FOR FREQUENCIES IN 400 800 1200 1600 2400 3600 CYCLE BANDS

MODEL 39-VTF, Series A, a new development of J-B-T engineers, measures frequencies in six specific bands with accuracy of ± 0.25% of the frequency being measured, and with sufficient amplitude to be easily read.

Vacuum tube multivibrator circuits divide the incoming frequency by 1, 2, 3, 4, 6 or 9, depending on the position of the multiplier switch, and show the result on the time-tested, standard 400 cycle meter.

Regular line current is used for power supply, permitting an input sensitivity of 500,000 ohms. Response is not affected by irregular wave form, nor by harmonic content of unknown frequencies of less than 10% or 15% . . . and input control permits use from 100 to 350 volts.

The result is an instrument of high accuracy and high stability with permanent calibration . . . especially useful for checking audio oscillators, frequency converters, radar equipment, and for standardizing less accurate frequency measuring units.

Check These Points

- EXTREME ACCURACY . . . within ± 0.25% of frequency being measured.
- PERMANENT ACCURACY . . . no further calibration or standardization required at any time.
- STABILITY . . . no temperature drift after initial 30 second warm-up.
- BURN-OUT PROOF . . . no protection needed against accidental above-range frequencies.
- SENSITIVITY . . . 500,000 ohms.
- SIMPLICITY . . . uses standard tubes.
- POSITIVE SWITCHING . . . built-in switch is J-B-T's own rugged, coin-silver plated instrument switch, as supplied for high quality testers.

New Booklet . . . just off press, illustrates other types of J-B-T Vibrating Reed Frequency Meters. Ask for Bulletin VF-43-1C.

J-B-T

Manufactured under J-B-T and/or Triplett Patents and Patents Pending

11-JBT-2

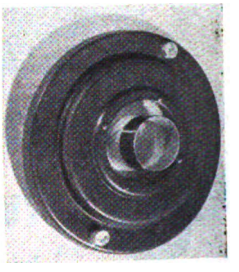
J-B-T INSTRUMENTS, INC.

431 CHAPEL STREET • NEW HAVEN 8, CONN.

1500 to 2000; dielectric constant, at 1000 cycles 3.0; power factor, at 1000 cycles 0.7 percent. Physical properties: Solid content (dried 3 hr at 135 C) 60 percent by weight; density 1.05 at 25 C; weight per gallon 8.75 lb; viscosity at 25 C, 2 to 5 poises; drying time to tack-free condition at 150 C, 1 to 4 hr.

New Loudspeaker Design

POSTWAR FEATURES of loudspeakers manufactured by Quam-Nichols Co., 33rd Place & Cottage Grove Ave., Chicago, Ill., incorporate a patented feature called the "adjust-a-cone". The spider of the loudspeaker is kept in position with a pressure or



clamping ring that is in turn held down by two machine screws. By loosening the screws holding the pressure ring, a small lateral movement of the spider is permitted by which the voice coil can be re-centered concentrically around the pole-piece and within the gap.

Vacuum Oil-Impregnated Transformers

TO EFFECT SUBSTANTIAL space and weight savings in transformers for airborne applications, the American Transformer Company (178 Emmet St., Newark 5, N. J.) has introduced Amertran hermetically sealed transformers which are vacuum oil-impregnated. They state this new process also increases the dielectric strength of the insulating medium and reduces corona effect. To compensate for pressure changes and make possible complete filling, the transformer-enclosing case was redesigned. The new case incorporates a bellows. Part of the new process includes a combination of heat to 230 F and an absolute pres-

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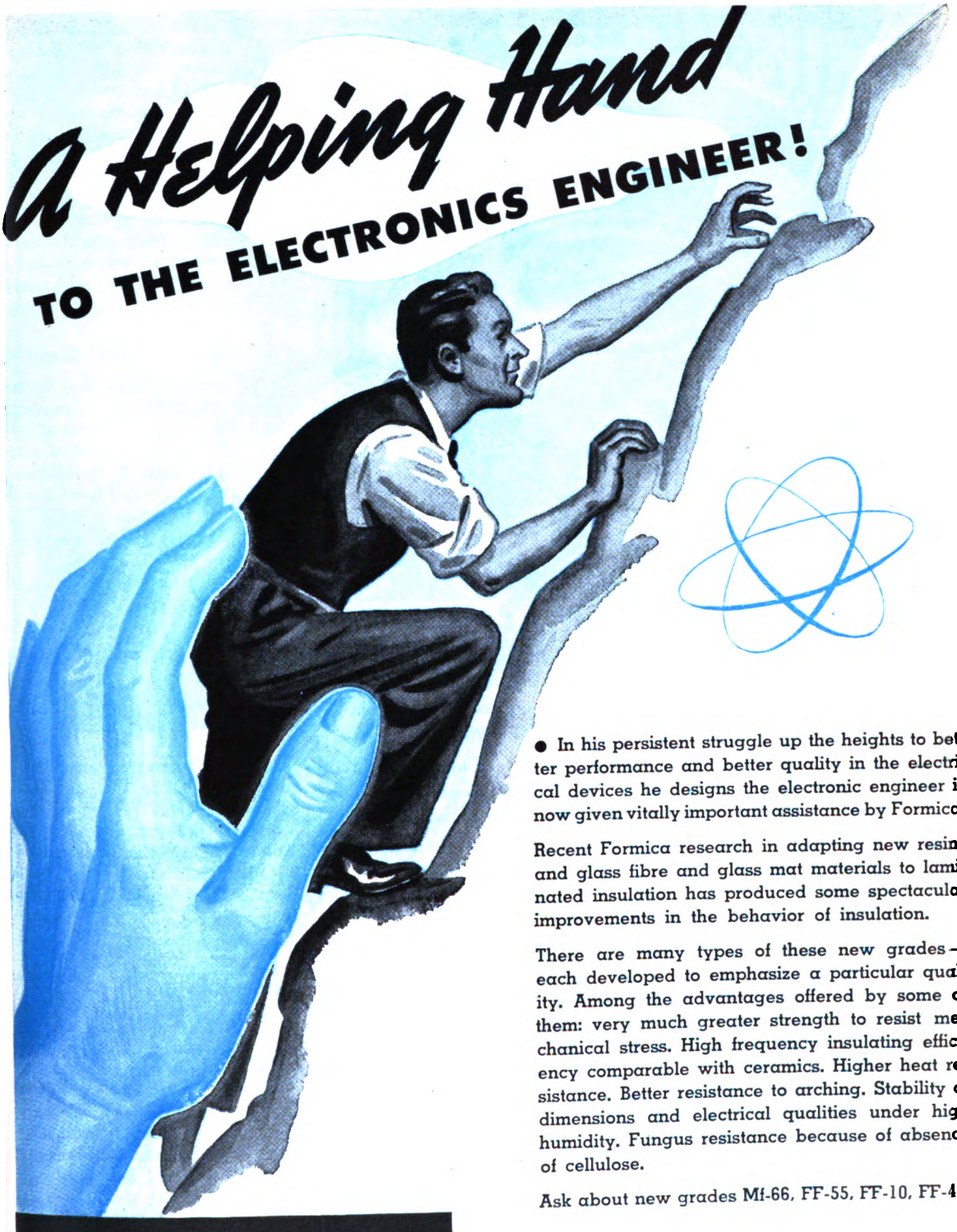
A Helping Hand

TO THE ELECTRONICS ENGINEER!



● In his persistent struggle up the heights to better performance and better quality in the electrical devices he designs the electronic engineer is now given vitally important assistance by Formica.

Recent Formica research in adapting new resins and glass fibre and glass mat materials to laminated insulation has produced some spectacular improvements in the behavior of insulation.

There are many types of these new grades — each developed to emphasize a particular quality. Among the advantages offered by some of them: very much greater strength to resist mechanical stress. High frequency insulating efficiency comparable with ceramics. Higher heat resistance. Better resistance to arching. Stability of dimensions and electrical qualities under high humidity. Fungus resistance because of absence of cellulose.

Ask about new grades Mf-66, FF-55, FF-10, FF-41.

FORMICA

THE FORMICA INSULATION CO.
4661 SPRING GROVE AVENUE
CINCINNATI 32, OHIO

275

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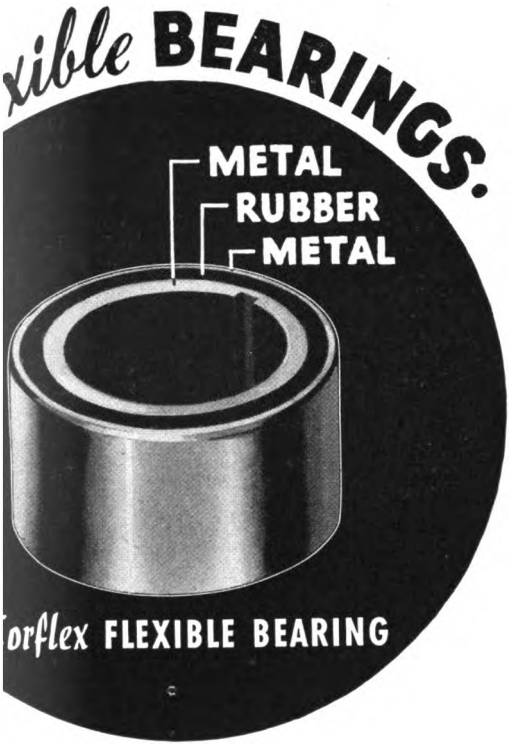


PIONEERING in the highly specialized field of engineered vibration and noise control, the Harris Products Company created and designed the widely used *Torflex Flexible Bearings.*

Torflex Flexible Bearings consist of a tube or ring of rubber stretched longitudinally between two concentric metal sleeves which prevent the rubber from returning to its original state. The pressure exerted by the rubber on the metal sleeves insures a high capacity mechanical bond between the rubber and metal under all operating conditions.

Torflex Flexible Bearings come in a wide range of sizes, consequently they have many applications in various fields. They control and eliminate vibration up to 90 percent, increase performance and efficiency of equipment and greatly prolong its useful life.

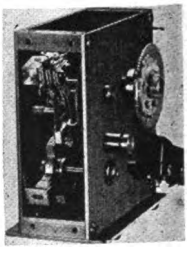
If yours is a problem involving vibration and noise drop us a line; our engineers will be glad to work with your engineers in its solution.

HARRIS
PRODUCTS COMPANY
CLEVELAND 4, OHIO
Branches: 44 Whitehall St., New York • General Motors Bldg., Detroit, Mich.

sure of 1 mm of mercury to rid the transformer oil of volatiles, air, and moisture. The oil is filtered to remove sludge and foreign matter. The transformers themselves are subjected to this combination of heat and vacuum for five hours to effect thorough dehydration. In addition to vacuum oil impregnation, the core and coil receive the vacuum varnish treatment. All units are tested under vacuum to detect the slightest possibility of leakage.

Constant-Speed D-C Motor

SMALL ENOUGH to be held in the palm of the hand, a new constant-speed d-c motor maintains a constant set speed regardless of variations in voltage. It is self-starting and builds up full speed almost



instantly. Current consumption is rated from 0.6 to 1 w, and shaft speeds may be geared from 1 revolution every 24 hr up to 600 rpm. Motors are available for use at 1½, 3, 6, 12, 24, 32 or 110 volts. Amglo Corp., 4234 Lincoln Ave., Chicago, Ill.

Direct-Reading Insulation Tester

THIS NEW INSTRUMENT, known as Model 799, is an extremely sensitive direct-reading insulation measuring device for applications where high testing potentials are not desired. It provides a single range for readings from 0.1 megohm to 10,000 megohm, with the 10,000 mark at 8 percent of the scale length, thus providing good readability. The circuit has a test potential of less than 50 volts d-c. An electrical guard circuit is provided for elimination of surface leakages when testing cables. All exposed parts are thoroughly insulated for operator's protection. A press-to-read

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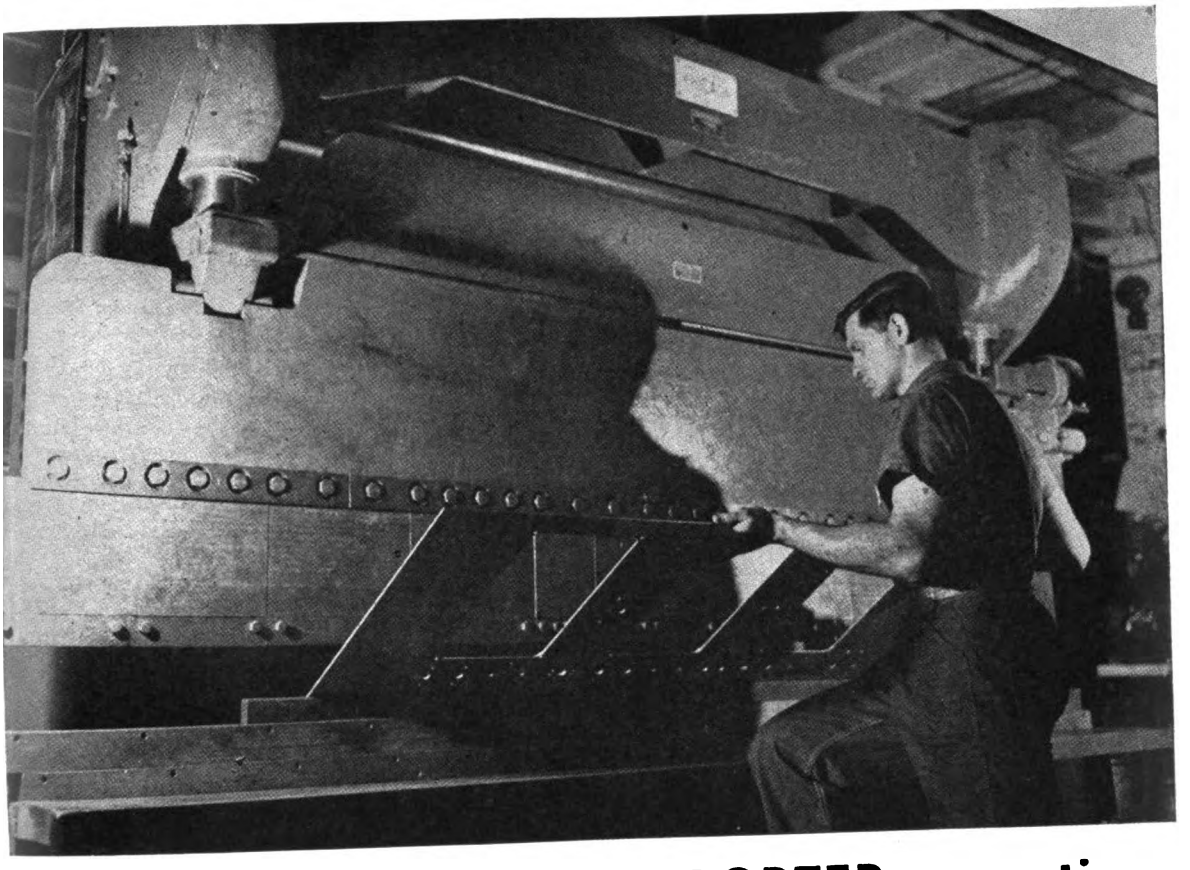
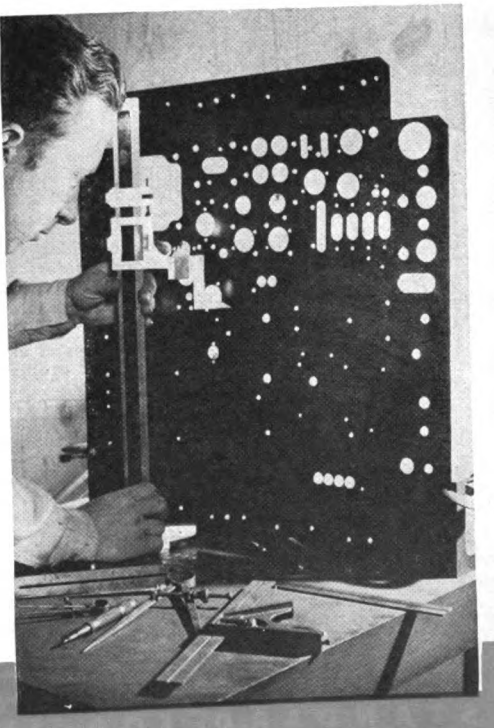


No "Margin for Error" in PORTER operations

When you require sheet metal work — in any metal — and PRECISION to close tolerances is a must . . . Porter has the experience and equipment to meet your needs to your complete satisfaction.

The skilled technicians and engineers of our thoroughly modern factory stand ready to help you work out money-saving and time-saving changes in design. Also, our large stock of available dies often helps speed up production while reducing manufacturing costs.

METAL BOXES * CASES * CABINETS * CHASSIS * ODD-SHAPED FLAT PIECES * STRIPS * PANELS * HOUSINGS * ETC.



PORTER METAL PRODUCTS COMPANY

121 INGRAHAM ST. BROOKLYN, N. Y.

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4 reasons why

Photo Courtesy of Crosley Radio Corporation

KESTER CORED SOLDERS

Are Industry's Standard

1. Kester Cored Solders are scientifically compounded to form clean, tight solder-bonds that hold *permanently* against shock, vibration, bending, and the contraction and expansion of temperature extremes.

2. Kester Cored Solders are applied in one simple operation. Virtually mistake-proof and trouble-free because the flux-filled core is perfectly balanced with superior alloys —and in the right combinations for every type of soldering.

3. Kester Cored Solders are of the highest quality and unvarying uniformity—the result of Kester's 46 years of practical experience and intensive research.

4. *Kester Rosin-Core Solder,* for electrical connections, and *Kester Acid-Core Solder,* for general work, are both available in a wide range of strand and core sizes. The correct solder, always, for any soldering job.

Feel free to call on Kester engineers at any time for help in solving your solder problems. There is no obligation!

★ BUY VICTORY BONDS ★

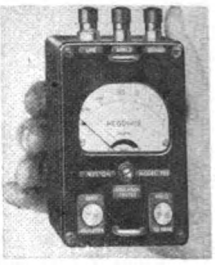
KESTER SOLDER COMPANY

4204 Wrightwood Avenue, Chicago 39, Ill.

Eastern Plant: Newark, N. J. Canadian Plant: Brantford, Ont.

KESTER *Cored Solders*

STANDARD FOR INDUSTRY



switch automatically disconnects the battery circuit when the instrument is not in use. Ferrules in the panel permit attachment to a lineman's belt or shoulder strap. The unit measures 5⅜ × 3¼ × 4¼ in. and is manufactured by Weston Electrical Instrument Corp., 617 Frelinghuysen Ave., Newark 5, N. J.

Tank Capacitor

ILLUSTRATED IS A large tank capacitor which was especially designed for a transoceanic transmitter. Its features are its space-saving design; the ability to operate under exacting circumstances with the

capacitance of much larger capacitors; and its low cost, which is 50 percent less than the type of capacitor it was built to replace. Cor-

Portable Power Supply

FEDERAL TELEPHONE & Radio Corp., Newark 1, N. J. has immediately available a portable d-c power supply unit (designated as FTR 3008-S), weighing only fifty pounds, which is convenient for laboratory and experimental work, or for public address systems. It can be used as a conversion unit in operating magnetic chucks, brakes, and all

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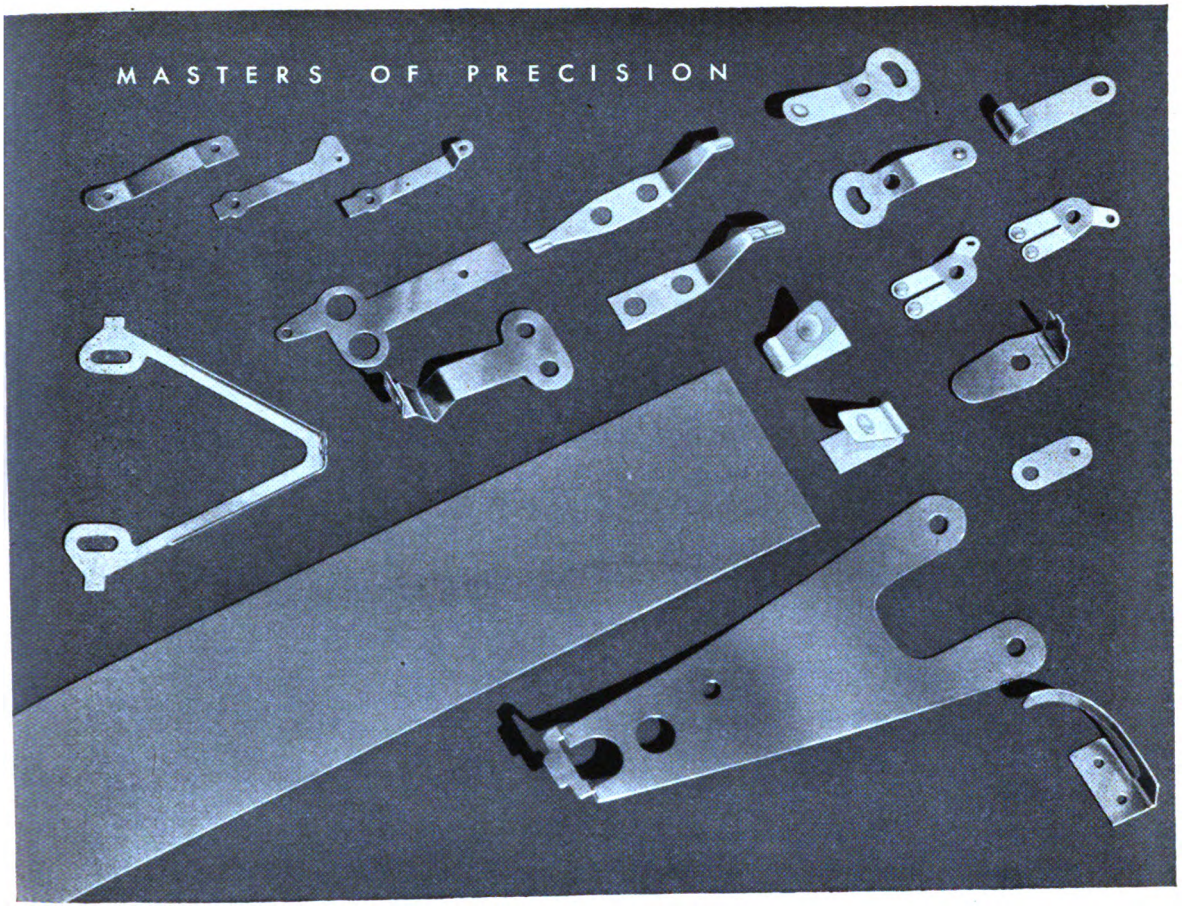

Western Metals Have *It*

One of the world's most successful manufacturers of control instruments requires a great variety of springs. Each, of course, must be uniform and precise in its functioning.

After many rigid tests, this manufacturer selected Western Super-X phosphor bronze and nickel silver to insure faithful functioning of his instruments.

These metals are especially treated to incorporate extraordinary ductility in combination with excellent spring properties.

Western Mills at East Alton, Ill., and New Haven, Conn., are strategically located to supply users of copper-base alloys. We will welcome your inquiry regarding "tailor-made" metals.

Western Super-X PHOSPHOR BRONZE
WESTERN BRASS MILLS

WESTERN BRASS MILLS

DIVISION OF OLIN INDUSTRIES, INC.

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BRASS • BRONZE • PHOSPHOR BRONZE • NICKEL SILVER • COPPER

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For more than 10 years

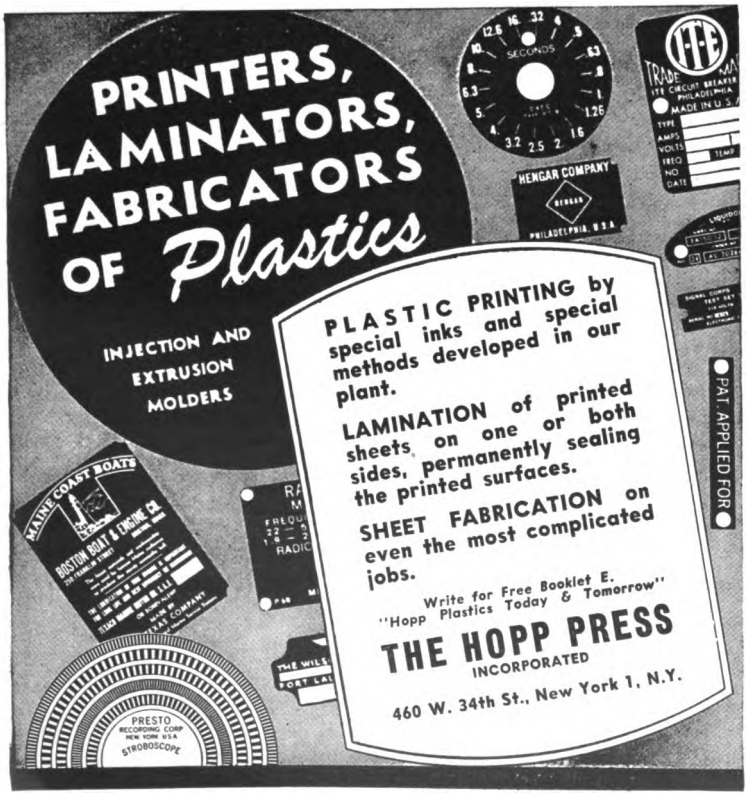
we have been manufacturing crystals. Not only are we crystal manufacturers, but crystal specialists as well. Consult us on your "crystal problems".

★

PETERSEN RADIO CO.

Council Bluffs, Iowa

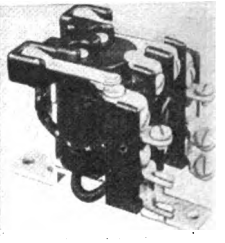
CRYSTALS EXCLUSIVELY SINCE 1934



similar activities, or as a means for testing electrical apparatus. The unit operates from any 115 or 230-v a-c outlet, and supplies from 5 to 10-v d-c power. The power supply is flexible; high or low voltage is available at the flip of a switch. Either output is adjustable by means of a 12-point primary tap switch. Federal's selenium rectifiers are used in units which are rated as follows: a-c input: 115 or 230 volts, 50 or 60 cycles, single phase; d-c output: 5 volts, 24 amp or 10 volts, 12 amp, resistive or inductive. Dimensions are: height 16½ in., width 10 in., depth 11 in.

Magnetic Relays

R-B-M MANUFACTURING Co., Logansport, Ind., announces a new and improved line of single and double-pole a-c and d-c magnetic relays for industrial and electronic applications. Ratings are: 10 amp at 24-v d-c and 110-v a-c; 5 amp at 220-v a-c; 1 hp single-phase 110 and 220-v a-c. Contact arrange-



ments are normally open, normally closed, and double throw, silver to silver. The armatures are self-aligning. All wiring terminals (either screw or solder) are easily accessible from the front. For complete interchangeability in mounting, both the a-c and d-c relays have identical bases. Relays may be mounted from front or rear. Bulletin No. 510 describes the d-c relays, and bulletin No. 550 describes a-c relays.

Complete Airport Radio Station

A COMPLETE AIRPORT radio station, Type RS-1 50-w unit, is offered by Aireon Manufacturing Corp., Kansas City, Kan. This station contains all necessary equipment (with the exception of antenna support-

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Upside down and sideways—and this transfermer puts in overtime!

This is just one more reason why Thermadors are known as America's quality transformers.

There is a machine called a Shaker. It goes up and down while it rotates. The motion varies from a gentle rhumba to an earthquake of cataclysmic proportions. In 10 minutes an ordinary transformer sails off into the steel mesh net.

At Aireon Manufacturing Corporation's Kansas City plant they bolted a Thermador transformer to the shake-bed of this machine. They turned the shaker on for an hour—then they left it going overnight, unbolted the Thermador transformer, connected it to the test line. The needle showed not an nth of variation.

Why this incredible performance? Just this. Transformers were formerly mounted to the cover of their cases. Thermador developed a strong stamped bracket from strip steel and projection-welded it to the case body—independent of terminal boards or covers. As a result, Thermador transformers can be mounted in any position—up and down and sideways—and take the worst beating you can give them.

THERMADOR ELECTRICAL MANUFACTURING COMPANY
5119 SOUTH RIVERSIDE DRIVE • LOS ANGELES 22, CALIF.

Thermador Transformers

DEFEAT COLD • HEAT • HUMIDITY

Seven Leagues Ahead

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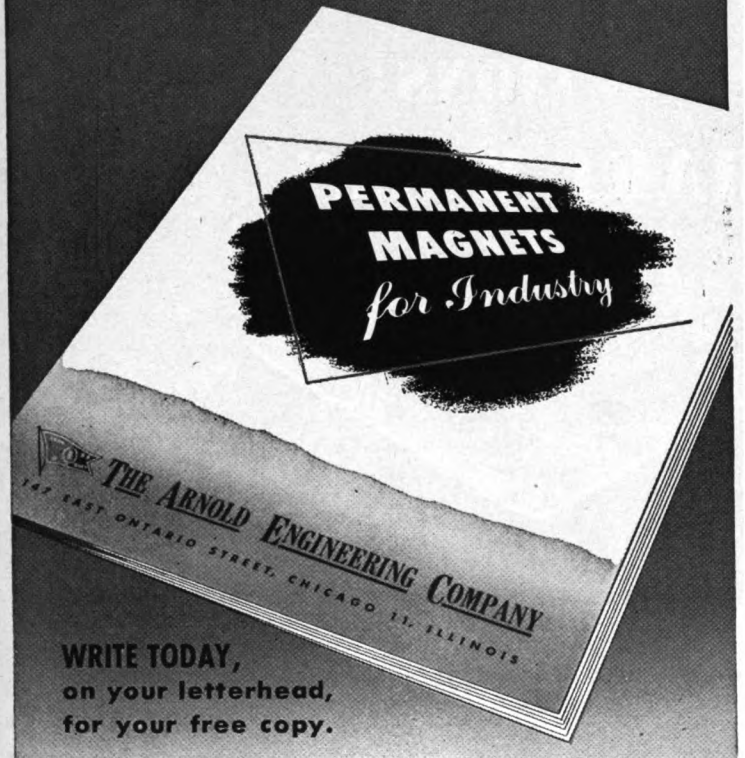
NEW! A complete, 24 page Illustrated Manual on *Permanent Magnets*



WRITE TODAY,
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This unusual Arnold manual on permanent magnets is the product of many months of careful research and planning.

It is devoted entirely to the consideration of the factors affecting the design, fabrication and application of Alnico permanent magnets. Written entirely by Arnold engineers, its purpose is to help engineers in industry to better utilize the magnetic and physical characteristics of the Alnico alloys in arriving at efficient design.

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Specialists in the Manufacture of ALNICO PERMANENT MAGNETS

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THIS NEW MIGHTY MIDGET

No. 412

has changed the lives of this whole family of "MINI-MAX" BATTERIES

The four batteries shown above are approximately ⅔ of actual size

EVEN BEFORE PEARL HARBOR, battery construction principles developed by National Carbon Company were making possible new strides in portable radio and electronic equipment. Then came the war. The company was called upon to develop even more radical improvements in battery construction to meet the needs of light and extremely portable military communications of all types, and so the tiny 22½ volt "Eveready" "Mini-Max" "B" battery was born—a battery well under half the size of anything of comparable voltage—easy to carry as a match box!

This is what this new, improved battery construction means. It means a brand new line of portable radio equipment—equipment that will give the idea of the "personal radio" an entirely new meaning. It makes possible radio sets for individual use—sets so small that they can be slipped into the pocket of a vest, or carried in a woman's handbag. Portable radio business will not merely pick up where it left off December 7, 1941. It will be years ahead of itself.

Engineers and designers are already aware of the possibilities of this new battery. They are already at work on new radio and electronic devices which exploit its portability. And at this time may we invite all these creative men to avail themselves of our experience, our laboratories and to consult with our engineers. National Carbon Company, Inc. extends to you complete cooperation.

The words "Eveready" and "Mini-Max" are registered trade-marks of National Carbon Company, Inc.

Now that radio batteries are back again, National Carbon Company is offering an extremely useful new Portable Radio Battery Replacement Guide. Write for your copy today to our nearest Division Office listed below.

NATIONAL CARBON COMPANY, INC.

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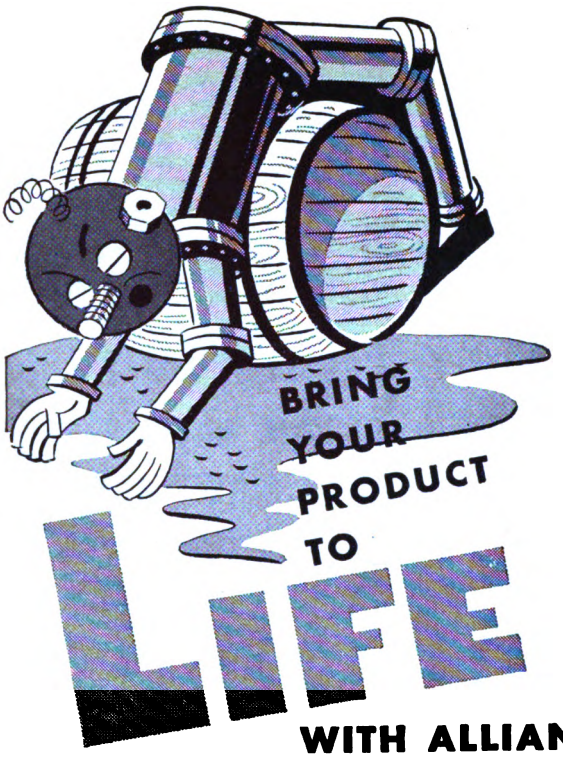


WITH ALLIANCE

When you want action—remote control, automatic or non-automatic, it will pay you to use Alliance Power Pact MOTORS. Not only in finished products, but as a flexible power source in your own industrial processes, these miniature power units really bring your product to life.

Here are just a few of the ways that Alliance motors can add to the usefulness of any machine, device or control. Of course there are many more!

Electronic and electric controls, time, temperature, pressure and humidity controls, coin operated phonographs, drink and merchandise dispensers, fans, valves and blowers, door openers, signals, motion displays, movie projectors and scores of industrial applications.

WHEN YOU DESIGN—KEEP

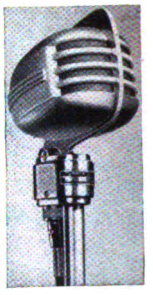
alliance

IN MIND

ALLIANCE MANUFACTURING CO. • ALLIANCE, OHIO

Colored Microphones

THE TURNER CO., Cedar Rapids, Iowa, is introducing a new line of microphones, called "Colortones," made in richly-colored plastic finishes. The material used in the new mikes is tough, resilient cellulose acetate. These plastic castings can be produced in a wide variety



of solid colors and pastels, mottles and striated effects. Although primary emphasis has been placed on outward appearances of the new models, research has gone into their interiors. Materials and techniques discovered during wartime are incorporated into the circuits of both the dynamic and crystal units.

Soldering Iron

THE BAKER Electronic Manufacturing Co., 3017 Lyndale Ave., South Minneapolis, Minn., announce a new gun-type soldering iron for industrial use. Two models available include No. SF-100 for fine

and general soldering and No. HF-150 for heavy-duty work. Features of these irons include trigger control, instantaneous heating and operation from a 110-v transformer or directly from any standard car or truck storage battery.

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AND NOW!

UNITED

Quality Standard

TER COOLED TUBES

progress of *United Electronics* been characterized over the rs, by the addition of new es in the higher power tagories. It is with reason- le pride therefore that e now announce UNITED ternal anode tubes in th water cooled and r radiator designs.

Type 893-A illustrated is rated for 20 KW anode dissipation and maximum power output of 50 KW. Write for engineering information bulletins on UNITED external anode tubes.

Masterpiece of Skilled Hands

Ruggedizing: A United feature which enables tubes to withstand terrific shocks.

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NEWARK 2, NEW JERSEY

nsmitting Tubes EXCLUSIVELY Since 1934

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Follansbee

SILICON STEELS

Follansbee is today producing Electrical Sheets and Strip which were not available a few short years ago. If your wartime production has not brought you into contact with these silicon steels, then make sure your new products are not unnecessarily limited by failure to take advantage of them.

Follansbee Electrical Sheets and Strip are made to the high standards in keeping with its tradition of generations of fine steel-making. Exacting specifications are met with a precision which minimizes your production difficulties.

You are invited to check your requirements for Electrical Sheets or Strip with Follansbee. Inquire through the General Offices or any Sales Office or Agency.

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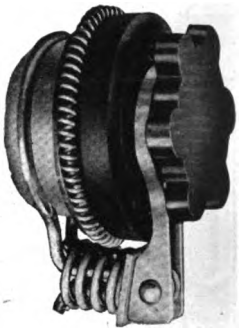
ALLOY BLOOMS & BILLETS, SHEETS & STRIP • CLAD METALS • COLD ROLLED CARBON SHEETS & STRIP
POLISHED BLUE SHEETS • ELECTRICAL SHEETS & STRIP • SEAMLESS TERNE ROLL ROOFING

Waterproof Jack Cover

THIS JACK COVER is a simple device which completely seals electrical jacks used in radio and electrical equipment. It is not affected by adverse marine or climatic conditions. In the accompanying illustration the hinged seal-plug is shown



closed; when open a telephone-type plug may be inserted through the jack cover into the jack in the normal manner. No special holes or tools are required for installation of the seal-plugs. Seal-plugs are available in either black or red color. Waterproof Electric Co., 72 East Verudgo Ave., Burbank, Calif.

X-Ray Unit

ILLUSTRATED IS a complete contact and cavity x-ray unit (Type M-33) which is designed especially for x-radiation of body surfaces and cavities in treating certain diseases. The internal construction of the tube used in the unit is such that it provides an extremely intense x-ray beam with low inherent filtration. The anode produces radiation within 18 mm of the cap. The intensity is approximately 8000 roentgens per minute at a distance of 18 mm from the focal spot.

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MITCHELL-RAND

VARNISHED TUBING HEADQUARTERS

Complete and Comprehensive is Mitchell-Rand's line of Varnished Tubings . . . Fiberglas or Cotton Yarn . . . to meet every known need of the Electrical or Electronic industries.

For Varnilshed Tubings that won't fray, burn or oxidize ...that will resist high temperatures, high dielectric and always remain flexible . . . check with Mitchell-Rand for the Varnished Tubing best suited to your needs.

FIBERGLAS *INORGANIC* VARNISHED TUBINGS

M-R Fiberglas Varnished Tubings are made in four grades:

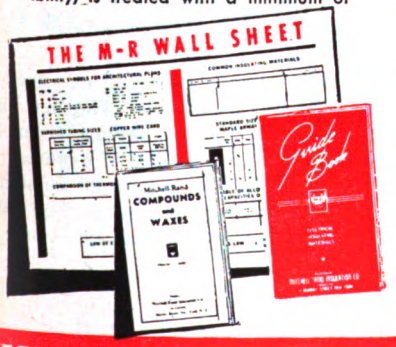
Standard; Double Saturated; Triple Strength and Impregnated.

STANDARD GRADE has maximum flexibility, is treated with a minimum of varnish and recommended for high temperatures where dielectric strength is not a factor.

DOUBLE SATURATED has all qualities of the Standard Grade but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

TRIPLE STRENGTH is built up with coats of especially flexible insulation varnish for dielectric ratings up to 3,000 volts and is particularly suited where assembly operations include the possibility of rough handling.

IMPREGNATED is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc IMPREGNATED has a dielectric rating beyond 8,000 volts and is unequalled for Long Life Under Most Severe Conditions. *Write For Samples.*



FREE FOR THE ASKING!
Write today for your Wall Chart with reference tables, electrical symbols, allowable capacities of conductors, dielectric averages, thicknesses of insulating materials and the M-R Wax and Compound Guide Book . . . they are full of valuable information . . .

FOR USERS OF COTTON YARN VARNISHED TUBINGS

The Mitchell-Rand MIRAC and HY-GRADE Varnished Tubings of long staple fibre yarn are comparable to Fiberglas Tubings in dielectric ratings, tensile strength, flexibility and long life.

MITCHELL-RAND *for 56 YEARS* THE ELECTRICAL INSULATION HEADQUARTERS

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Fiberglas Varnished Tape and Cloth
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Cable Filling and Pothead Compounds
Friction Tape and Splice
Transformer Compounds

Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevings
Impregnated Varnish Tubing
Insulating Varnishes of all types

Fiberglas Saturated Sleeving and Varnished Tubing
Asbestos Sleeving and Tape
Extruded Plastic Tubing
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth and Tubing

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The urgent demand, in peacetime days, by the aircraft and radio industries for a compact, efficient D.C. motor was the challenge that led Pioneer to develop the Pincor BX series. Today Pincor BX motors flow from our plant in a steady stream to the producers of aircraft and radio equipment for the armed services.

Pincor BX motors, in their classification, meet the varied requirements of aircraft and radio manufacturers that demand light weight, compact motors for efficient and dependable application. Pincor BX motors are direct drive, ball bearing, high speed units wound for continuous or intermittent duty. Shunt, series or split series windings are for operation on 12 to 24 volt battery systems currently used and may be easily modified to meet your product demand.

Depend on these rugged Pincor quality-proven motors in the BX series. Send your problem to Pioneer engineers and let them put their years of experience to work for you. Consultation with these men will not obligate you in the least.

DYNAMOTORS • CONVERTERS
GENERATORS
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CORPORATION
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Export Office, 25 Warren Street, New York 7, U.S.A.
Cable Address: Simontrice, N. Y.

BUY MORE BONDS!

The entire apparatus (including the tube and control) is constructed to protect the operator against electrical shock and stray radiation. The tube weighs but 11 lb so that it is easy to manipulate. Special cones and applicators adapt the equipment to a wide range of applications. Controls include the main switch, adjustment switch for line voltage, voltmeter, tube-filament control and milliammeter. A built-in timer with a range from 5 sec to 5 min insures accuracy of treatment time. The power supply unit has a rectifier tube and a capacitor to supply d-c having a low percentage of ripple. North American Philips Co., Inc., 100 East 42nd St., New York, N. Y.

Selenium Rectifiers

A LINE OF SELENIUM rectifiers, manufactured by Radio Receptor Co., Inc., of 251 West 19th St., New York, N. Y. utilize, in the main, aluminum in place of iron or similar metals. The units are hermetically sealed to assure maximum

performance under all extremes of climatic conditions. The new line includes units ranging from 25 mils up to capacities of hundreds of amperes, for use in all combinations of voltage and current outputs and for various types of circuits.

Shock-Resistant Ceramic

INDUSTRIAL ELECTRONIC manufacturers may be interested in a new ceramic material developed by General Ceramics and Steatite Corp., Keasbey, N. J. This material withstands temperature shocks from approximately 1400 F to the tempera-

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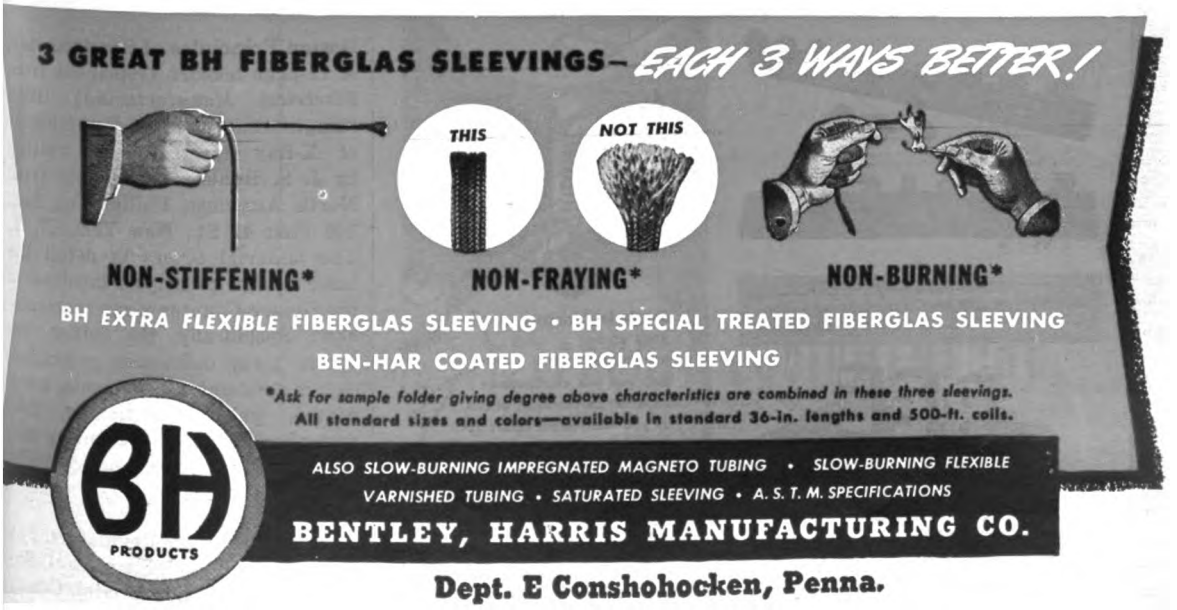
WHETHER he's Mr. Big of Industry or plain Mr. Homebody, the performance of your product's electrical insulation can make or break *his* good will, influence *your* future sales. Look at *all* the hazards of faulty or insufficient insulation. See why hundreds of manufacturers are protecting *their* products with BH Fiberglas Sleeving—the insulation that's way ahead in every important requirement, thanks to the *exclusive* BH process.

BH Fiberglas Sleeving is *permanently* flexible and non-fraying, the *original* sleeving to combine these qualities with heat resistance to 1200°F., with high tensile strength, and with resistance to moisture, oil, grease and most chemicals. It's easier to handle and install, and lasts longer in severest service. That's why BH Special Treated Fiberglas Sleeving, for instance, does a trouble-free job when the heat's on—why Mr. Room Heater Customer is sold *for good* when the heater's BH-equipped.

Whatever your product may be, if it depends on electrical insulation, you can count on one of the three BH Fiberglas Sleevings to meet your strictest needs. Send for free BH samples *today* —test them yourself—expect surprising results!



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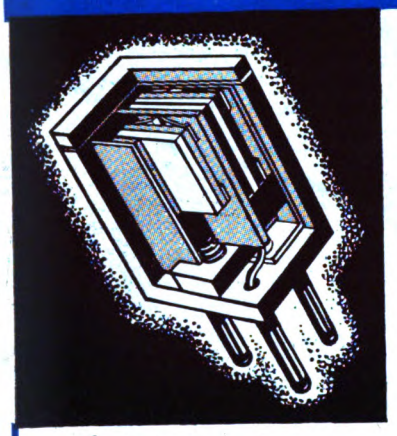
Specialists in Special Crystals



POLICE AND AIRCRAFT

A clamped type crystal which must pass Signal Corps and Coast Guard Class A specifications. Stays permanently at desired frequency - less than .01% drift over minus 30°C to plus 50°C temperature range. Shown at left is a dual unit for transmitting and receiving. Unusually stable and therefore ideal for Police cruisers, boats and aircraft. Available from 1000 to 10,000 KC.

24 HOUR SERVICE

ORDERS FOR STANDARD TYPE CRYSTALS FOR AIRLINES, POLICE, AND OTHER EMERGENCY USES WILL BE FILLED WITHIN 24 HOURS FROM THE TIME THEY ARE RECEIVED

Yankee Ingenuity makes us SPECIALISTS IN SPECIAL CRYSTALS

Write Dept. E.L. for comprehensive catalogue "Selectronic Crystals" and facilities booklet "Crystalab Solves a Problem"

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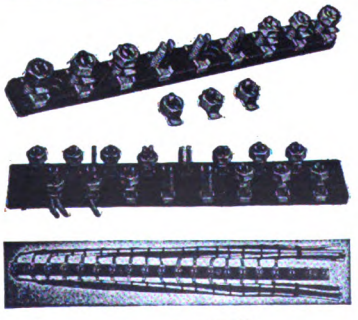
LOCK A WIRE TO A WIRE

When the Bee nut is screwed down all the way, its built-in clamp locks a wire to a wire. No danger of loose strands. Assures a vibration-proof, low resistance connection.



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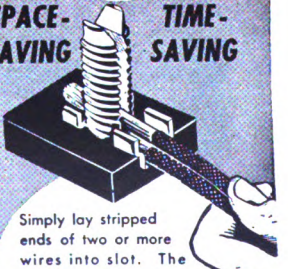

Simply lay stripped ends of two or more wires into slot. The Bee nut will clamp them together permanently or until you want them apart. No lugs, lock nuts or lock washers required. No soldering, crimping, pressing or insulating.

BEE TERMINAL BLOCKS LOCK A WIRE TO A WIRE

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ture of ice water, without cracking. The material is characterized by its extremely low thermal expansion coefficient which is in the range of Invar (1.6×10^{-6} up to 600 F and 1.9×10^{-6} up to 1000 F). The ceramic withstands a temperature of 2500 F and has a dielectric strength of 90 volts per mil. The dielectric constant at 1000 kc is 5.30 and the power factor is 0.54 percent. The manufacturer suggests the ceramic can be used in precision instruments where the low thermal expansion coefficient of a high-quality ceramic part is most desirable.

Literature

Electric Shock Hazard. A 34-page booklet entitled "Measurement of Electric Shock Hazard in Radio Equipment" is published by Underwriters' Laboratories, Inc., 161 Sixth Ave., New York 13, N. Y. This bulletin provides a general description of the factors relating to electric shock in radio receivers. A summary of the data from the literature furnishes background information regarding limits for the measurements and for the choice of a testing instrument. The development of a suitable vacuum-tube voltmeter (diode-peak meter) is described and its use is explained.

Design Principles of Spectrometer. A 12-page booklet (reprinted from *Electrical Manufacturing*) titled "Engineering-Design Development of X-Ray Spectrometer", written by J. S. Buhler, is available from North American Philips Co., Inc., 100 East 42 St., New York, N. Y. The material covers in detail the basic design principles involved in the Geiger-Counter x-ray spectrometer. Specifically, the author discusses x-ray diffraction principles, new instrument requirements, x-ray source, pulse conditioning, frequency meter circuit, counting meter circuit, meters and controls, and applications.

Automatic Voltage Regulators. For automatic line voltage control, Superior Electric Co., Bristol, Conn.,

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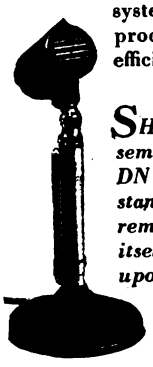

SHOWN in the installation pictured above is a Dynamic, semi-directional, all-purpose Microphone of the Astatic DN Series, mounted on Grip-to-Talk Desk Stand. This stand embodies a relay-operating ON-OFF Switch for remote control of transmitters and amplifiers, the switch itself being operated by a slight pressure of the fingers upon a convenient grip bar.

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manufactures many types of automatic voltage regulators which are described in their bulletin No. 164. The Bulletin also describes Models 4101R, 4101H, 4102H, and 4106H which are now provided with a rapid-trip magnetic circuit breaker for overload protection and also as an on-off switch.

Quartz Crystals. An 8-page bulletin describes such crystals as supersonic curves, spherical or flat crystals for all uses; filter crystals (minimum drift) for precise frequencies; 100-kc frequency standard crystals which withstand severe shock and vibrations; 200-500 kc extremely stable crystals for high output and keying; and crystals for portable use in police and aircraft communication. These crystals are manufactured by Crystal Research Laboratories, Inc., 29 Allyn Street, Hartford 3, Conn., from raw quartz to the finished crystal.

Precision Tuning Fork. A low-frequency tuning fork with a vacuum-tube drive is described in a recent issue of General Radio Experimenter, published by General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass. Other articles in this issue of interest to readers include "Balancing to 0.000070 Inch With the Strobotac" and "Production Testing With Impedances".

Allis-Chalmers. Two pieces of literature recently issued by Allis-Chalmers Manufacturing Co., Box 512, Milwaukee, Wis., include a "Directory of Products and Engineering Literature" which lists products made by Allis-Chalmers. Among these are electronic heaters ranging from 400,000 cycles and up which are described in Bulletin No. B-6372. The second piece of literature is titled "1944 Annual Review" which records the past year's engineering developments at Allis-Chalmers.

Silicones. Compounds and greases, fluids, varnishes and resins, and silastic silicones are described in a 12-page booklet available from Dow Corning Corp., P. O. Box 592, Midland, Mich.

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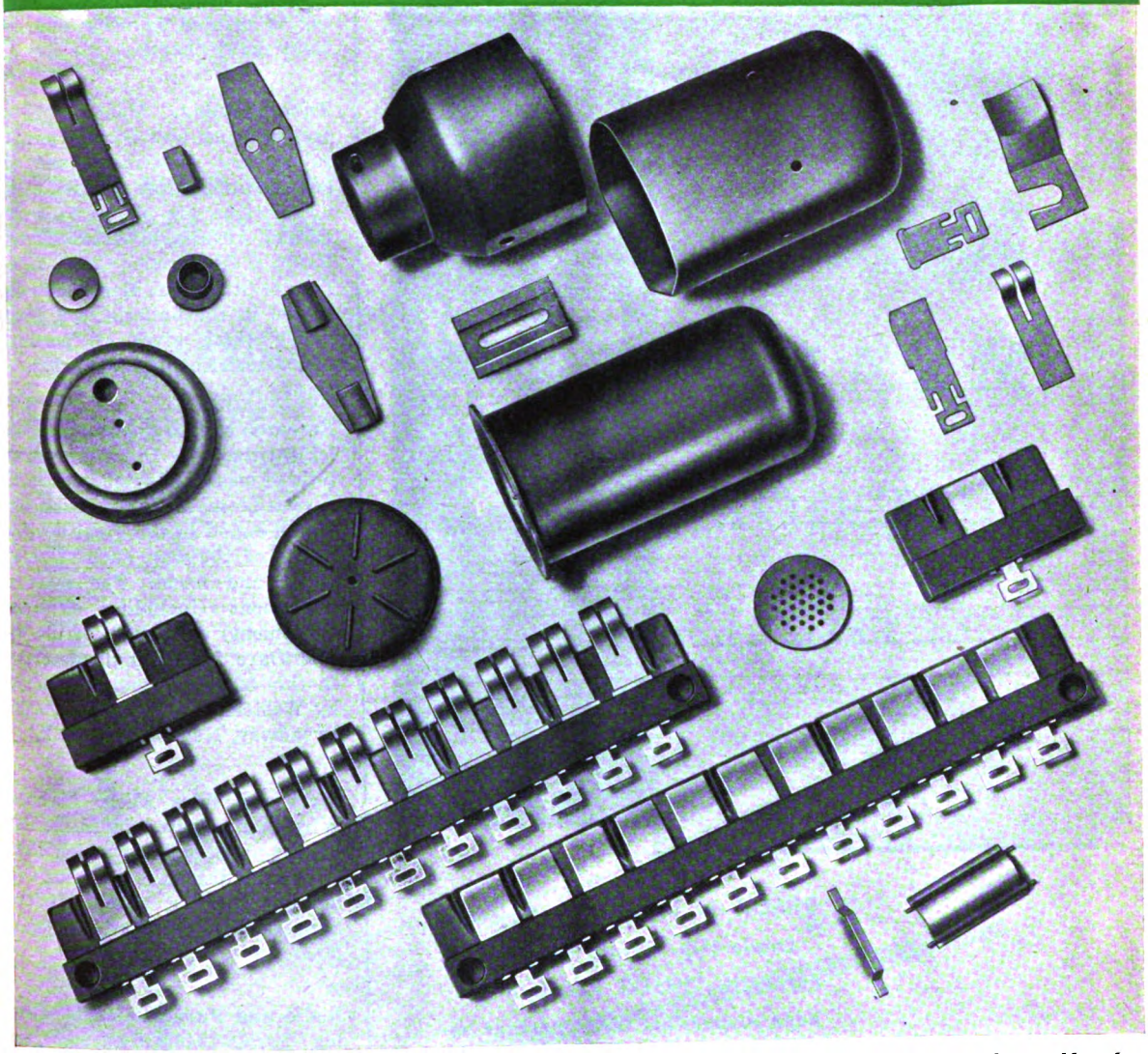

Lower production cost becomes increasingly important as the American manufacturing industry moves rapidly into the bright new era of peacetime production. At the same time, the American market will demand that quality be maintained at the highest possible economic level.

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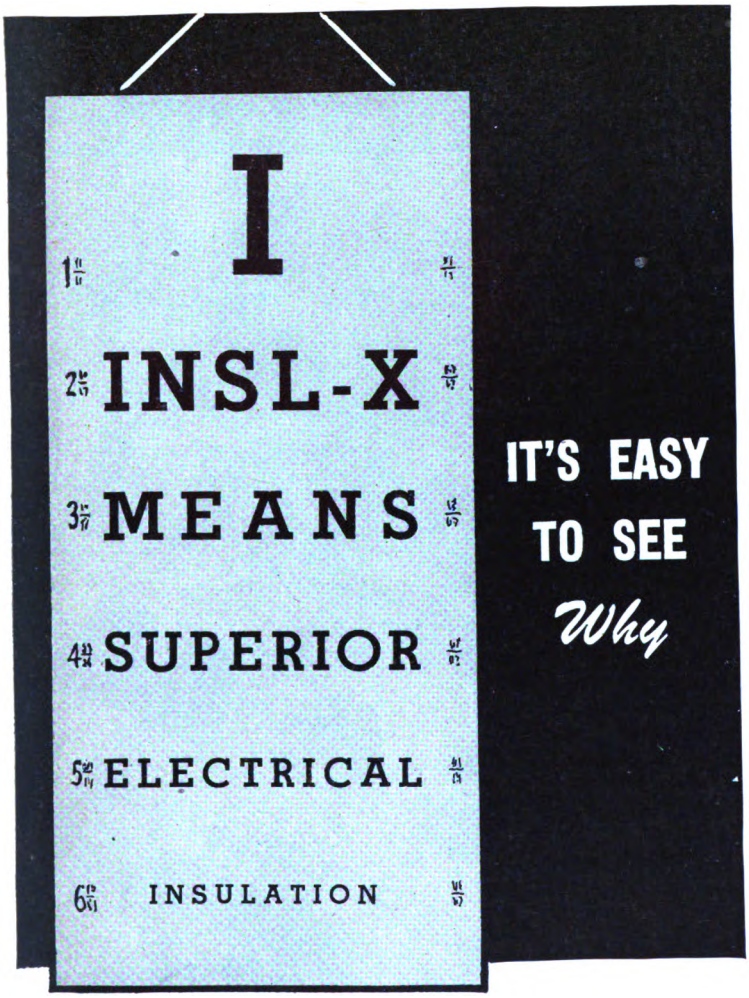

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Literature Upon Request

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Erie Resistor Catalog. Performance data and specifications of resistors, ceramicons and silvered mica capacitors are contained in a new catalog available from Erie Resistor Co., Erie, Pa. The catalog is printed in color and contains many charts.

Tube Catalog. Many types of transmitting and special purpose tubes are illustrated and described and bottom views of socket connections are shown in a new catalog available from Hytron Radio & Electronics Corp., 76 Lafayette St., Salem, Mass. Also contained in the bulletin is a 4-page chart which gives all pertinent characteristics of these tubes.

Research and Engineering. A booklet entitled "We Did It This Way" tells of small but vital steps in the forward march of technology which ended in the great developments of the war, such as sonar, radar and loran. The types of equipment (including electronic equipment) developed for the war effort are interestingly described in this 32-page booklet published by Western Electric Co., Inc., 195 Broadway, New York 7, N. Y.

Steel and Wire Alloy. "Spencer Wire Comes Through" is the title of a 4-page bulletin which illustrates and describes precision wire and gives a list of applications. Spencer Wire Co., West Brookfield, Mass.

Radio and Phono Cabinets. Catalog Series-1946 illustrates and describes 28 different types of cabinets and cases available from Radio Merchandise Sales, 550 Westchester Ave., New York 55, N. Y.

Television Receivers. A large brochure illustrates and briefly describes projection-type television receivers for the home and for commercial use; direct view receivers for the home, classic and modern cabinets, all manufactured by Allen B. DuMont Laboratories, Inc., 2 Main Ave., Passaic, N. J. under the registered trademark of "Teleset".

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War Developed, RADIART MIDGET VIBRATOR has Many Applications!

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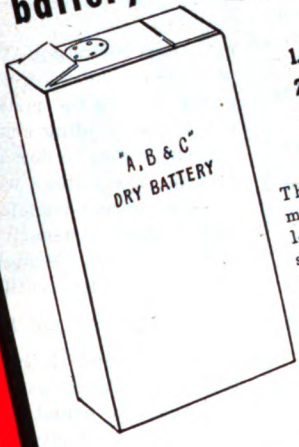
WAR NEED POINTS ONE IMPORTANT USE

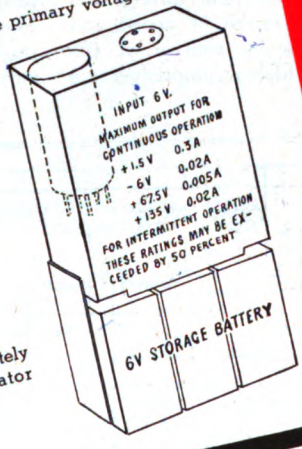
A VIBRATOR OPERATED POWER SUPPLY WAS REQUIRED . . . to replace a dry battery and with same dimensions . . .



THE REQUIREMENTS WERE:

1. To supply A, B and C Power equivalent to dry battery
2. Infinite shelf life before usage.
3. To operate from a rechargeable primary voltage source

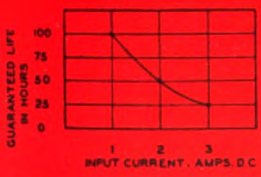
The original dry battery measured only 6-1/2"x 3-1/2"x 1-3/4". Within these dimensions RADIART produced a completely filtered, well regulated vibrator power supply and included provisions for a rechargeable storage battery



This necessitated the development of a completely new split-reed synchronous midget vibrator known as the Radiart Type VR-2

P- PRIMARY
S- SECONDARY
R- REED

The RADIART VR-2 Midget Vibrator can now be produced for civilian applications. Will this be of help in your product? Send us full information as to your requirements...our engineering department will fully cooperate.



SPECIFICATIONS

Vibrator Frequency . 185 CPS ± 10%
Input Voltage, Nominal . . . . . 6.0 V.
Input Voltage Range . . 4.5 to 7.5 V
Output Voltage . . 200 V. D.C. Max.
Potential Difference
Between P_R & S_R . . . . 25 V. Max.

Manufactured by makers of famous RADIART Rust Proof Aerials.

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INDUSTRIAL CONTROL

Electronic Regulator for Arc Furnaces..... 314
Phototube Weft Straightening..... 316
Circuit of Electronic Capacitance-type Fuel Gage..... 324
Automatic Tuning of R-F Heating Generator..... 332
Electrostatic Paint Spraying and Detearing..... 336
Brazing Operations in Transmitter Tube Assembly..... 340
Electronic Balancer for Rotating Parts..... 364

Electronic Regulator for Arc Furnaces

AS THE CHARGE in an arc furnace melts down, it is necessary that the electrode be lowered to maintain the arc. Withdrawal becomes necessary when melting scrap falls against the electrode, causing a short circuit. And normal consumption of the graphite in the electrode calls for a corresponding adjustment.

A recent Westinghouse development is an electronic unit which gives a wide range of speed and quick response in control of the motor drive which accomplishes this regulation. The system works by varying the armature voltage of a constant-field motor to produce the required speed of electrode motion.

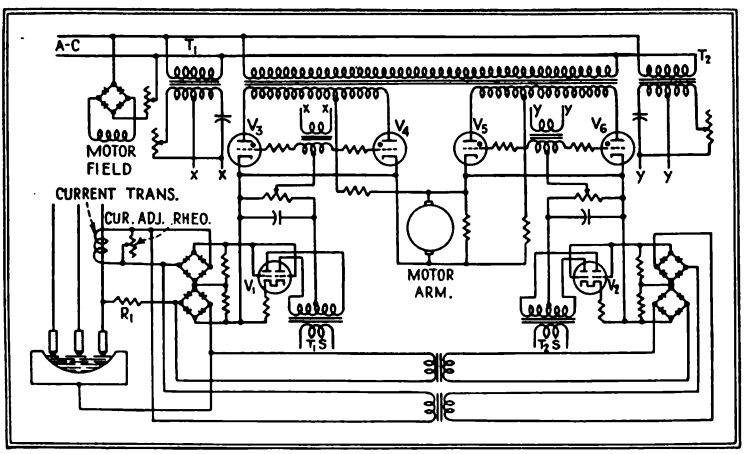

Fig. 1—Circuit of the electronic arc-furnace regulator. Tubes V_1 and V_2 regulate the firing of thyratrons V_3, V_4, V_5, and V_6, each pair of which is related to one direction of electrode-motor rotation

Circuit of One Channel

Figure 1 discloses the general scheme of the equipment. It shows three-phase electrodes but includes details on only one of the regulating channels. Also, certain elements of the grid balancing circuits have been omitted in the interest of a simplified diagram.

Grid control voltage proportional to electrode current is taken from the current transformer shown in the electrode circuit and passed through the upper of the pair of full-wave dry rectifiers connected to V_1. Another grid control voltage proportional to the arc potential comes through R_1 and the shell of the furnace to the other dry rectifier of the pair.

When operation is begun with the closing of the main circuit breaker, voltage on the potential circuit drives the cathode of V_1 positive, reducing plate current and the voltage drop across the potentiometer. This makes the grids of V_3 and V_4 less negative so the tubes start conducting. They then supply full-wave rectified voltage to the electrode motor in the direction necessary to produce lowering of the electrode.

As the first electrode strikes the metal, the voltage drops to zero. This produces an increase in the plate current of V_1 and a resulting increase in grid voltage on V_3 and V_4 which blocks their conduction

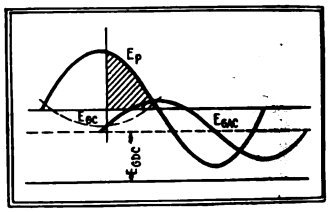

Fig. 2—Phase-angle firing control is used in the arc-furnace regulator. Variations in E_{GDC} cause E_{GAC} to intersect the E_{GC} curve at different points, instituting conduction for the remainder of the half-cycle. Motor power is represented by the shaded area

and stops the motor. When the second electrode in the three-phase group strikes the metal at the end of a corresponding chain of events, current begins to flow in both. This results in a voltage which appears in each current-transformer circuit and imposes a negative voltage on the grid of V_2 through its associated pair of dry rectifiers.

Positioning the Electrode

Tubes V_3 and V_4 then perform in the same fashion as V_3 and V_4 except that the armature voltage has the opposite polarity and drives the motor in the opposite direction, raising the electrode and establishing an arc whose voltage increases and current decreases as it lengthens. Ultimately a balance is established between the potential and current grid-control voltages and the electrode position is established. Thereafter, variations arising through diminishing electrode length, melting down of the metal, or a cave-in around an electrode, supply grid voltages such as to produce appropriate motion of the affected electrodes.

Variable voltage for the motors is obtained by superimposing an a-c voltage wave on the d-c grid voltage of the main thyratron tubes V_3, V_4, V_5, and V_6. Because this has a 90-deg lag behind the thyratron anode voltage, it cuts the critical grid-voltage line at different points as

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PERMANENT LOW UNIT COST

CLOSE TOLERANCE LIMITS

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QUALITY

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TYPE ALA — 3 WATTS
MAX. RES: 25,000 Ohms (Nichrome)
MAX. RES: 5,000 Ohms (Manganin)
BODY SIZE: 1⅛" Lg. by ⅜" Dia.
MOUNTING: By Axial Leads
TERMINALS: No. 18 Tinned Copper Leads, 2 Inches Long
TOLERANCES: Standard 3% (1% at Slight Extra Cost)

TYPE ACA — 6 WATTS
Same as Type ALA except coated with high temperature cement.

TYPE BLA — 5 WATTS
MAX. RES: 50,000 Ohms (Nichrome)
MAX. RES: 10,000 Ohms (Manganin)
BODY SIZE: 1⅝" Lg. by ⅜" Dia.
MOUNTING: By Axial Leads
TERMINALS: No. 18 Tinned Copper Leads, 2 Inches Long
TOLERANCES: Standard 3% (1% at Slight Extra Cost)

TYPE BCA — 10 WATTS
Same as Type BLA except coated with high temperature cement.

Types ALA, ACA, BLA, BCA can be supplied with non-inductive winding with 50% reduction in maximum resistance. Add suffix "N" to code when specifying non-inductive types (ALAN, ACAN, BLAN, BCAN).

Dependable!

This new line of resistors—designed to meet current demands for small, low-cost, quality units of close tolerance—is immediately available. They cover the full range from 1 watt to 10 watts and 1 ohm to 1 megohm. Designed for long life and stability, these components have hard soldered connections between resistance wire and terminals, assuring permanent noiseless, trouble-free units. These new resistors are engineered for the manufacturer who desires to retain a reputation of top quality and performance in his equipment. Like all IN-RES-CO products they are produced under rigid control by modern facilities. Write for details.

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NON-INDUCTIVE

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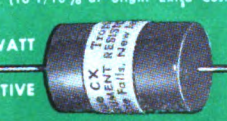
TOLERANCES: Standard 3%
(To 1/10% at Slight Extra Cost)

TYPE CX-1 WATT
NON-INDUCTIVE



MAX. RES: 500,000 Ohms (Nichrome)
MAX. RES: 15,000 Ohms (Manganin)
BODY SIZE: ¾" Lg. by 9/16" Dia.
TOLERANCES: Standard 3%
(To 1/10% at Slight Extra Cost)

INSTRUMENT RESISTORS CO.
25 AMITY STREET, LITTLE FALLS, NEW JERSEY

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the d-c grid voltage is raised or lowered. Figure 2 shows this relation which allows the thyratrons to conduct for varying portions of a half cycle.

For a high degree of accuracy in a system like this, the various grid voltages must have complete control over the regulating tubes without causing them to saturate because of the grids swinging positive. The self-biasing resistor is arranged so that the regulating tube works along the straight portion of its curve like a class-A amplifier. This results in high amplification, and a small change in grid voltage varies the output of the regulating tube over a wide range. A wide range of current adjustment is obtained by means of a rheostat shunting the current transformer. This method maintains the same sensitivity for all current settings.

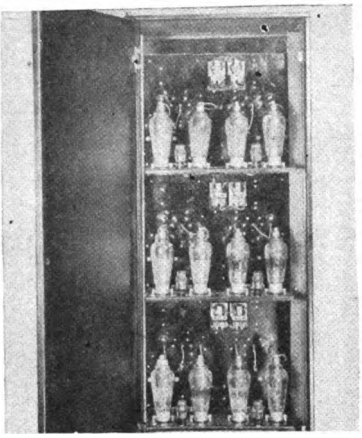

Fig. 3—Closeup view of the three channels of thyratrons and coordinated regulator stages for a three-phase arc furnace in their protective housing

Provision for controlling the electrodes manually, either individually or in a group, facilitates handling during charging, pouring, and changing electrodes. Physical construction of the unit which houses the gear is shown in Fig. 3. The control panel is disposed for setting into the wall of the furnace vault in accordance with standard practice with other types of regulators. Single-unit construction, as in this design, eases the problem of excluding dirt and protecting the apparatus against physical damage. It also facilitates factory testing of the whole operation including the electrode motors.

Phototube Weft Straightening in Textile Industry

IN A TEXTILE INDUSTRY control produced by General Electric Co., a pair of exciter-lamp and phototube scanning units count the number of weft threads at each side of a continuously moving web of cloth, compare them to detect skew, and provide impulses by which automatic correction is made. The controls are used in conjunction with weft-straightening equipment made by Winsor & Jerauld Mfg. Co.

Shown in Fig. 1 is a typical installation. A single unit is to be seen in Fig. 2 with parts marked. The method of operation is revealed in the succeeding figures. Light beams *A* and *B* as illustrated in Fig. 3X are produced in the optical system which mounts below the moving cloth as can be seen in Fig. 2. These beams are approximately 2½ by 0.004 in. and are reduced to spots, *C* and *D*, by rotating disks. Motion of the light spots bears a direct relation to the cloth speed, a relation which is maintained

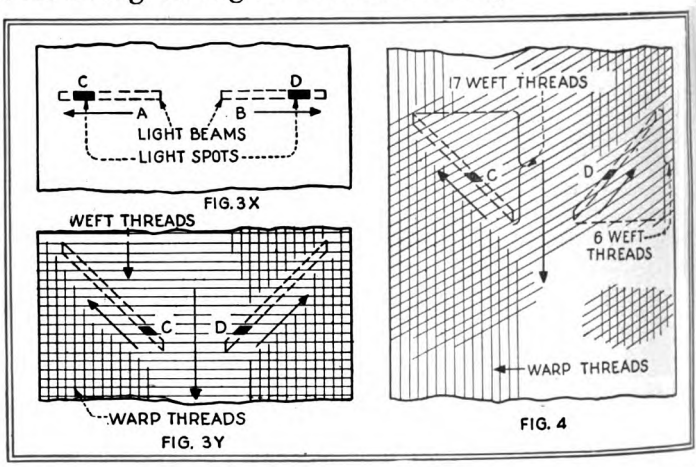

Fig. 3—Light beams shown at X are focused directly at the level of cloth, originating in optical system below. Selsyn-driven rotating disks cut beams down to spots. Effect when cloth moves is shown at Y

Fig. 4—When weft threads in moving cloth get askew, the spot of light on the leading side (left in this example) cuts across a greater number of threads to produce a higher frequency signal in the phototube

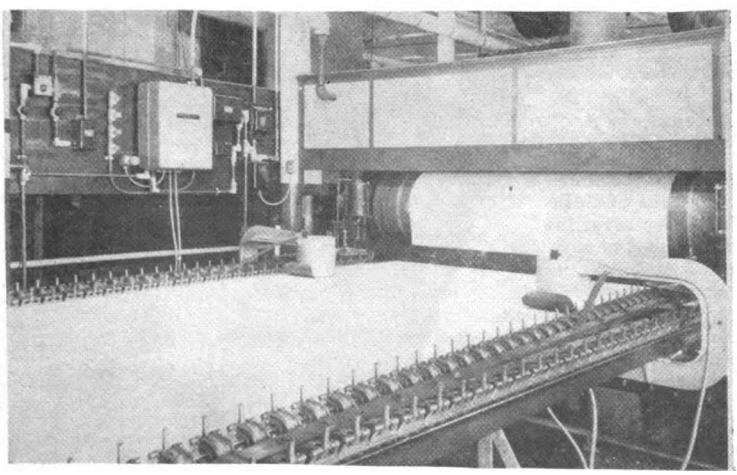

Fig. 1—Phototube weft straightening installation at Danvers Bleachery and Dye Works, Peabody, Mass. The light sources are below the level of cloth in the tenter

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LUGS, TERMINALS, FUSE CLIPS

throughout the speed range of the tenter by selsyn motors controlled by a transmitter on the main tenter drive. The relation is shown in Fig. 3Y where the cloth is in motion with weft threads straight.

When weft threads are askew as in Fig. 4, the light spot at the right

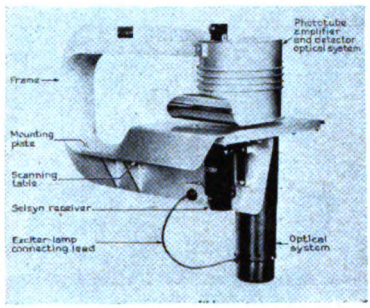


Fig. 2—Closeup of one of two units in a GE phototube weft-straightening control. Amplifier output goes to control unit and thence to operate straightening motor

intercepts more threads than does the one at the left. For skew in the opposite direction, the opposite situation prevails. Phototubes and related amplifiers are located in the cylindrical housings immediately above the moving cloth, where they receive impulses at the frequency of the passing threads—the same if the weft is straight but unequal in case of a skew.

Amplifier outputs are fed to a frequency-sensitive circuit in which a voltage output is produced

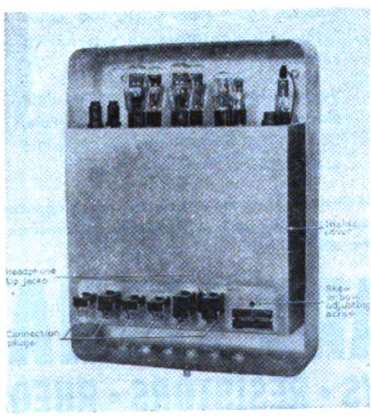
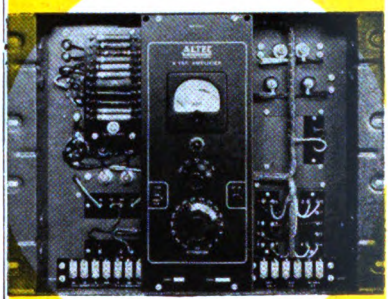


Fig. 5—Dustproof cover has been removed to show disposition of parts in weft control unit which is fed signals from the phototube amplifiers atop the sensing units

AN AMPLIFIED ANSWER TO AN ENGINEER'S DREAM

PARTICULARLY PERFECTED FOR PRE-EMPHASIZED DISC RECORDING



A new Altec Lansing 35 watt, 65 db gain, premium quality A255 amplifier, with plenty of reserve power and flat over the entire frequency range, has been particularly perfected for the requirements of high power at high frequencies as required for pre-emphasized disc recording. Curves, specifications and performance data will be sent immediately upon request. Refer to Altec Lansing's new A255, 35 watt, amplifier.

ALTEC LANSING CORPORATION

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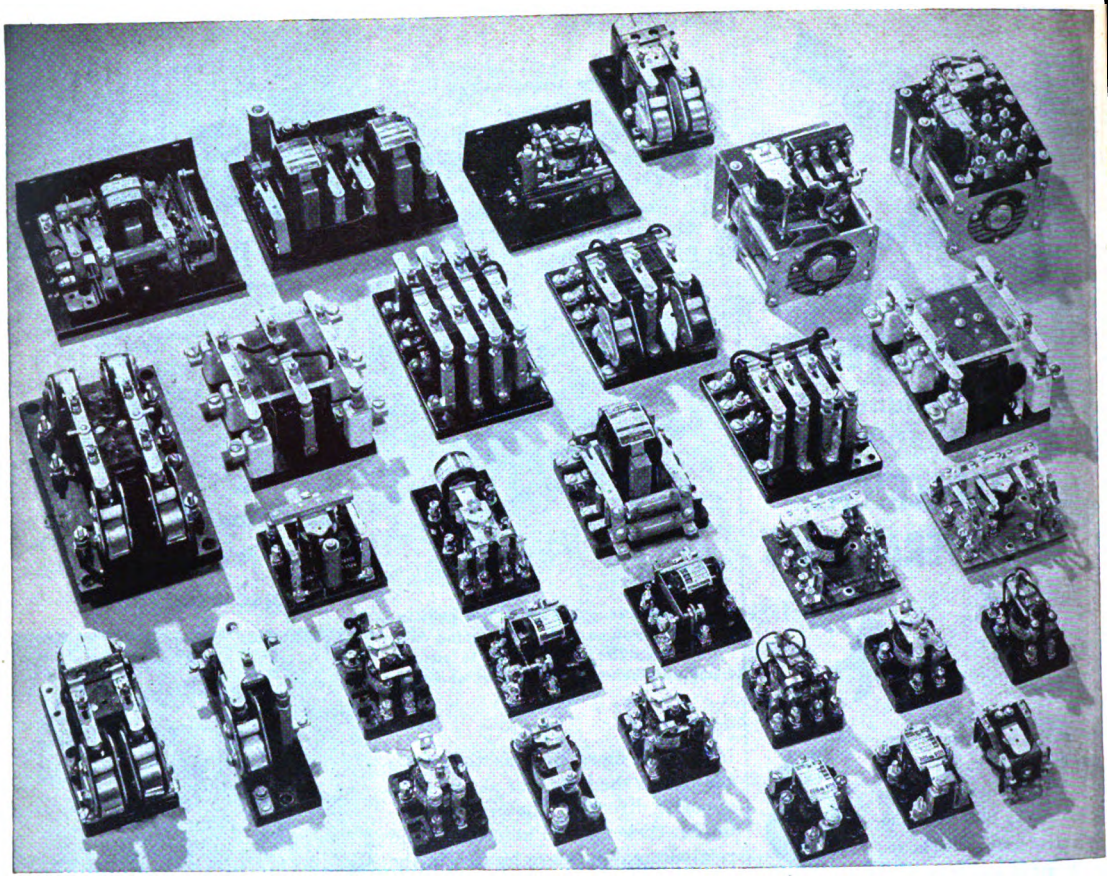

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Bulletin 105 — "Little Giant Relay" single pole, single and double throw. Controls ¾ HP on 115-230V.

Bulletin 106—Midget Relays for light duty available in single and double pole, single and double throw.

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WARD LEONARD RELAYS include types and sizes for every application. They all have crisp action, are dependable and durable yet consume but little current. Send for the data bulletins of interest to you.

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BECKMAN Helipot

Now available for civilian electronic applications!

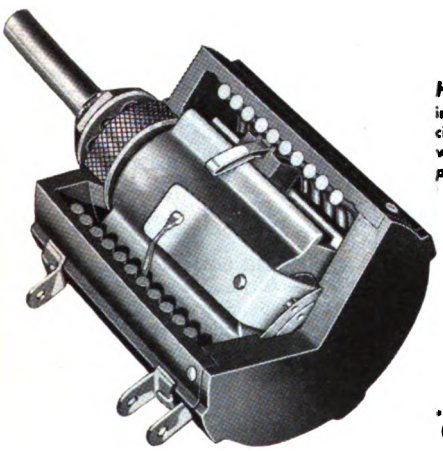
Can you use this important development to improve your product?

THE HELIPOT—a Beckman development widely used during the war on such precision instruments as radar, flight control units, depth sounding devices, and other critical electronic equipment—is now available to manufacturers and users of civilian electronic instruments!

The Beckman Helipot is a unique *new type* of potentiometer-rheostat which combines in *one compact unit* both the wide resistance range and extreme fineness of adjustment heretofore usually obtainable only through use of *two* separate rheostats, *two* control knobs, *two* adjusting operations. It is outstanding for all types of precision electronic equipment requiring high linearity, wide range and precise resistance control.

WHAT IT IS: The Beckman Helipot consists of a long, precision slide wire coiled helically into a small case and equipped with a slider contact assembly that is moved in the usual manner—by rotation of a shaft. A simple device automatically guides the slider contact over the helical path of the resistance winding so that the entire length of the wire can be contacted by rotation of *one* knob.

This unique design enables the Helipot to occupy no more panel space than a conventional single-turn rheostat. Yet the greatly increased length of the resistance winding provides a new standard of high accuracy *and* wide resistance range *in one unit*. It means, for example, that a ten-turn Helipot has *ten times the fineness of adjustment* possible with a single-turn rheostat of the same range. Or conversely, for the same fineness of adjustment a ten-turn Helipot has *ten times the range*.



IMPORTANT HELIPOT FEATURES

High Linearity—As a result of fulfilling wartime requirements for ultra-precision circuit controls, Helipots are mass-produced with linearity tolerances of *one tenth of one per cent*—and even less!

Precise Settings—Because of the many-times longer slide wire, settings can be made with an accuracy impossible with single turn units.

Wide Range—By coiling a long potentiometer slide wire into a helix, the Helipot provides *many times* the range possible with a single turn unit of comparable diameter and panel space requirements.

Low Torque—Of special interest for power-driven applications—the Helipot has unusually low torque characteristics. The 1½" Helipot, for example, has a torque of *only one inch-ounce*.

Write for further details!

*HELIPOT—T. M. Reg. (from HELical POTentiometer)

The Beckman Helipot is precision-built of the finest materials and is designed for use in all types of high quality electronic instruments where accuracy, sensitivity, wide range and positive operation are required. Why not investigate its use to increase the accuracy, the convenience, the efficiency of your quality electronic products? Our engineers will be glad to explain how the Helipot can fit your application. Write, briefly outlining your needs and ask for Helipot Bulletin!

VARIOUS SIZES AND TYPES

Current Helipot production is in several types and sizes, including . . .

Diameter	No. of Turns	Total Length Slide Wire
1½"	Up to 10	Up to 44"
3"	Up to 40	Up to 378"

Other sizes available on special order.

THE Helipot CORPORATION, South Pasadena, Calif.

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Palnut LOCK FASTENINGS assure Speedy, Low Cost Assembly!

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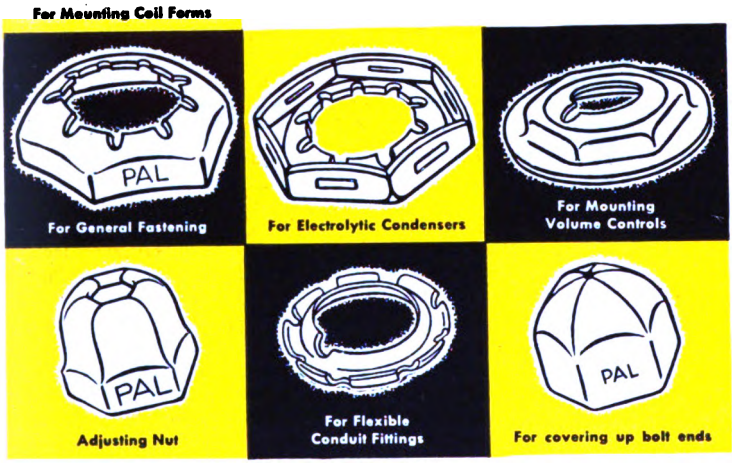

Replace slower, costlier 2-piece fastenings

DOUBLE LOCKING ACTION

This cross-section of a regular Palnut shows the unique double locking action typical of all Palnuts. When the Palnut is tightened, its arched slotted jaws grip the bolt like a chuck (B-B), while spring tension is exerted upward on the bolt thread and downward on the part (A-A), securely locking both.

Self-locking Palnuts are especially adapted to fast-moving assembly lines. One Palnut replaces a regular nut and lockwasher, cutting cost of fastenings in half. You handle one part instead of two, reducing assembly time 50%. Palnuts apply speedily with hand, Yankee or power drivers—extra fast when special Palnuts sockets are used.

Palnuts are single thread, spring tempered steel locknuts. They fit in the same area as hex nuts. Their extremely low cost, plus assembly savings, provides substantial economies on mass-production items such as radios, electrical appliances, etc. Palnuts are available in a wide range of types, sizes, finishes and materials.

Send details of assembly for recommendation and samples. Write for detailed folder on Self-Locking Palnuts.

THE PALNUT COMPANY., 77 CORDIER ST., IRVINGTON 11, N. J.

Self-Locking PALNUTS

The One-Piece fastenings with the Double-Locking Action.

proportional to the magnitude and also the direction of the skew. This voltage is used to control the operation of a straightening motor through the action of suitable electron tubes, no mechanical contactors being used in the gear.

Figure 5 shows the control unit in its dust-tight case. All external connections are made through non-interchangeable plugs. To facilitate maintenance, inoperative units are arranged for easy removal and replacement by factory adjusted units.

• • •

Circuit of Electronic Capacitance-type Fuel Gage

OPERATING DETAILS OF the aircraft fuel level gage developed by Minneapolis-Honeywell Regulator Co. and previously* described in general terms have been made available:

Operation of the gages is based on the general concept of the a-c bridge, discussed earlier** in connection with automatic pilot functions. The practical working circuit appears in Fig. 1. Sensing elements, as shown at the upper

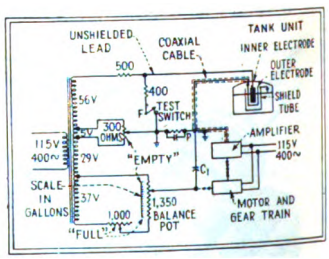

Fig. 1—The capacitance-type fuel gage utilizes this bridge circuit. The sensing element in upper right is a triple-coaxial aluminum tube

right, consist of concentric aluminum tubes of which the inner two form the opposite plates of a capacitor while the outer one serves as an electrostatic and mechanical shield and is grounded.

Gasoline flows through vents into the space between the tubes, varying the dielectric constant and thus changing the capacitance in a set relationship to the amount of fuel

*See, More Accurate Liquid Level Indicator for Aircraft Industry, ELECTRONICS, July 1945, p 152.
**See, Electronic Autopilot Circuits, ELECTRONICS, Oct. 1944, p 110.

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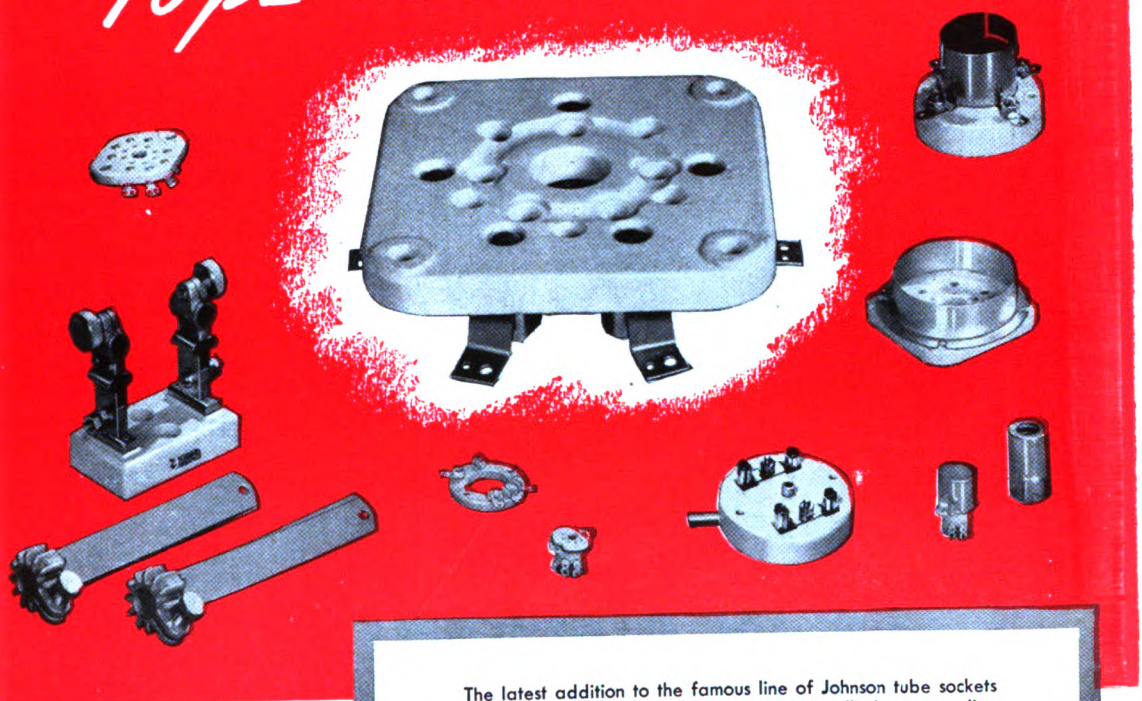
Tops in the Field



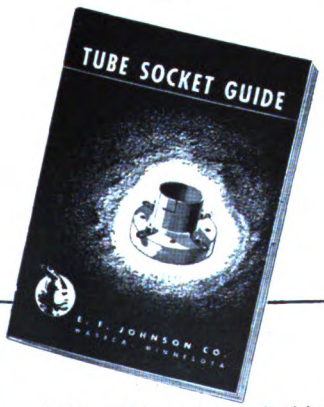
The latest addition to the famous line of Johnson tube sockets is the 275, Giant Five Pin socket with all the oustanding features which have made other Johnson sockets superior. A special feature of the 275 is the provision that has been made to allow forced ventilation from below the chassis, as required for the recently announced Eimac 4-125A and 4-250A. This socket may also be used for other Giant Five Base tubes when a wafer type socket is desired.

Johnson sockets are engineered to meet the most exacting requirements of industrial, commercial broadcast and "ham" applications. For more than 20 years Johnson engineers have designed, and Johnson production lines have produced, transmitting components known throughout the industry as tops in the field. With this background and the close association with tube manufacturers, Johnson is continually leading the way with tube sockets designed to meet the rigid requirements of present day electronic circuits and equipment.

If you have a special tube socket problem, write Johnson, today.

Write for

TUBE SOCKET GUIDE



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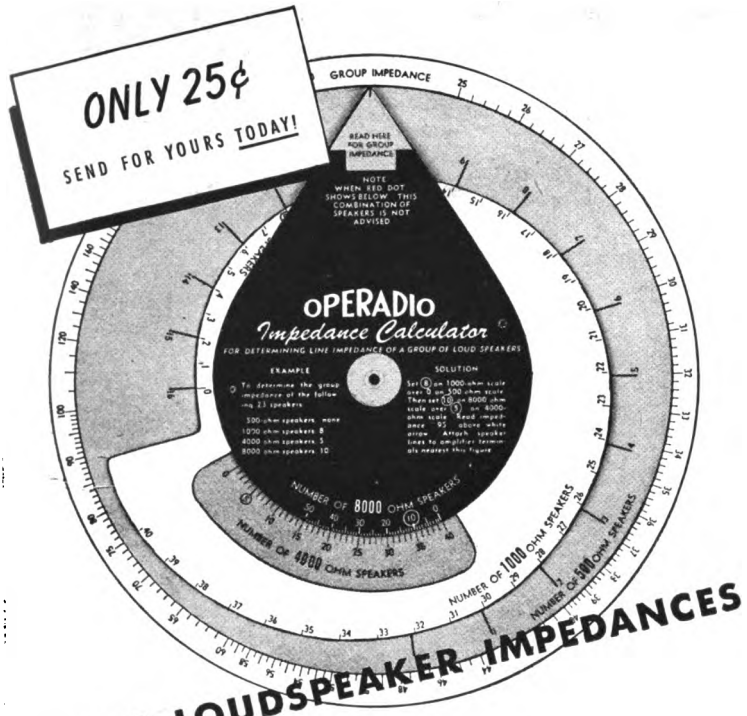

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in the tank. Liquid gasoline has a dielectric constant of about 2 whereas a mixture of gasoline vapor and air has a constant of about 1. This gives a capacitance variation of nearly twice for the difference between an empty and a full tank, a variation which is independent of fuel temperature.

Thermal Compensation

Temperature changes have a dual effect on gasoline. Thermal expansion is accompanied by a reduction in dielectric constant, which means that as a temperature increase causes the fuel to rise in the sensing tube, the resulting capacitance increase is opposed by the falling dielectric constant of the whole. See Fig. 2. Being based on capacitance, the indication of the gage, therefore, can be calibrated in gallons at 77 F or on a basis of weight which relates directly to engine power as volume does not.

For an example of the magnitude of error possible in a mechanical gage which can only measure volume, a plane taking off in India where ground temperatures run as

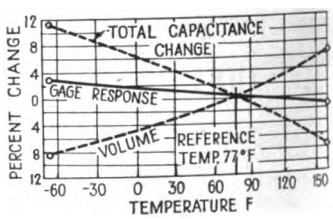

Fig. 2—Plot of temperature against percent change shows the opposition effect of volume and capacitance with resultant gage response

high as 140 F and climbing to 30,000 ft (minus 40 F) would lose fuel volume of 12 percent from shrinkage. Other factors such as play in linkages and sloshing of fuel, make it possible to gain as much as 15 percent in accuracy by capacitor-type sensing units.

In the bridge circuit of Fig. 1, the two arms consist of the capacitance of the tank unit and the fixed capacitor C_1 with unbalance voltage appearing across the transformer tap and point P. When the fuel level changes, unbalancing the bridge, this unbalance voltage signal is fed to a phase-sensitive amplifier which

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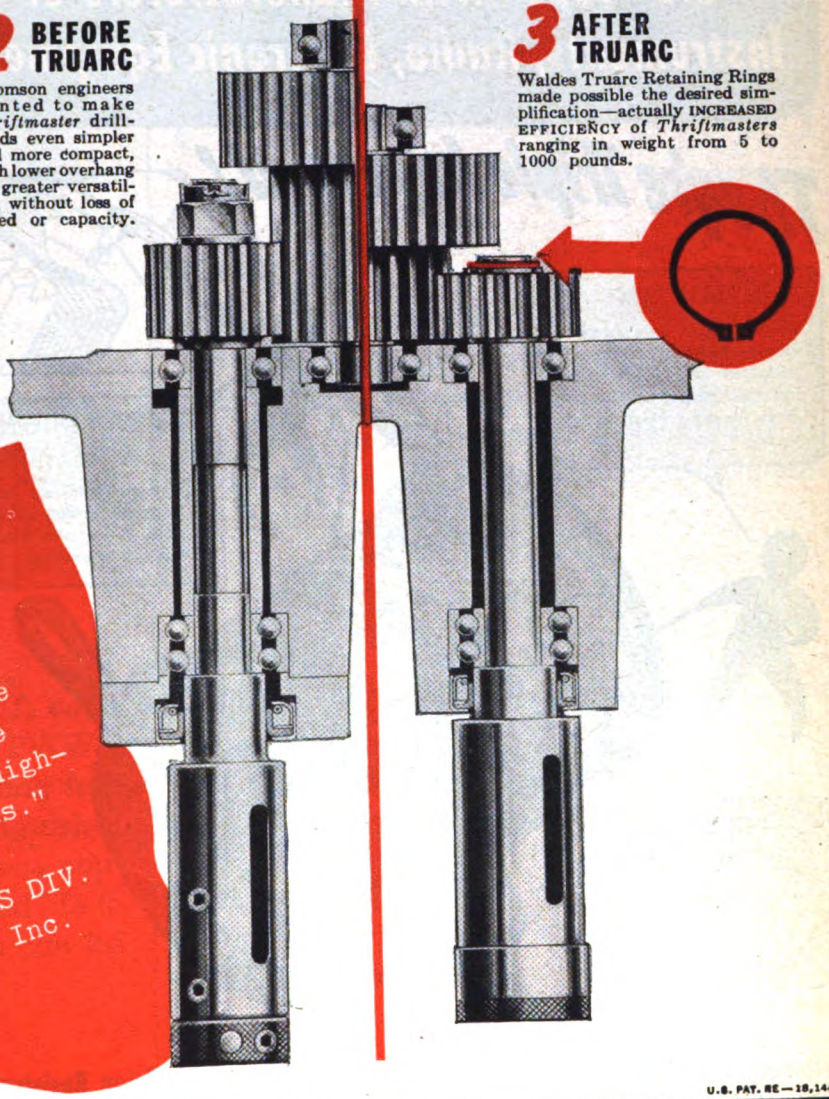
Another Proof that Waldes Truarc Retaining Rings hold moving parts together better!

2 BEFORE TRUARC

Thomson engineers wanted to make *Thriftmaster* drill-heads even simpler and more compact, with lower overhang for greater versatility, without loss of speed or capacity.

3 AFTER TRUARC

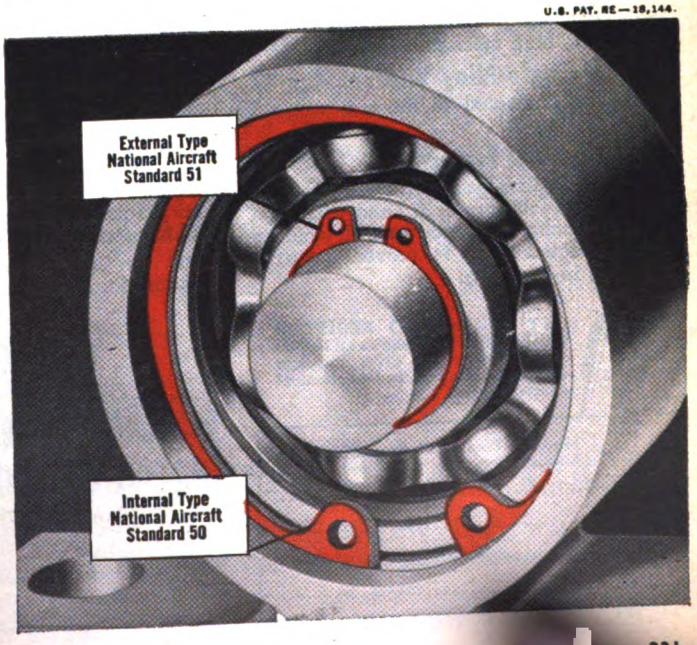
Waldes Truarc Retaining Rings made possible the desired simplification—actually INCREASED EFFICIENCY of *Thriftmasters* ranging in weight from 5 to 1000 pounds.



...des Truarc Retaining Rings ...bled us to make substantial ...me and labor savings in ...roduction of THRIFTMASTER ...drillheads...and made possible a much lighter, handier, more rugged tool, exceeding our high-est performance requirements."

(Signed)
THRIFTMASTER PRODUCTS DIV.
Thomson Industries, Inc.

U.S. PAT. RE—18,144.



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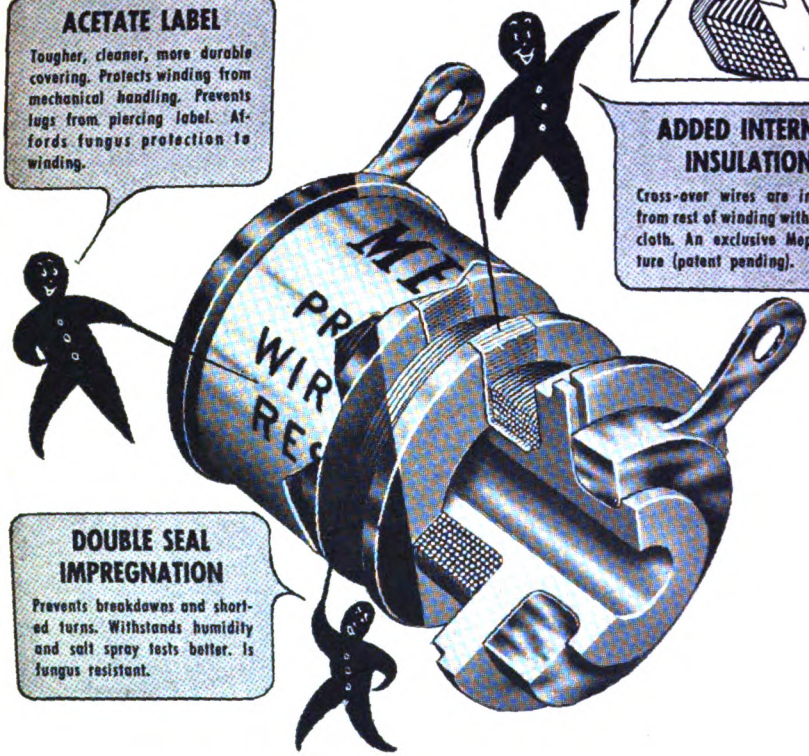
Cross-over wires are insulated from rest of winding with acetate cloth. An exclusive Mepco feature (patent pending).



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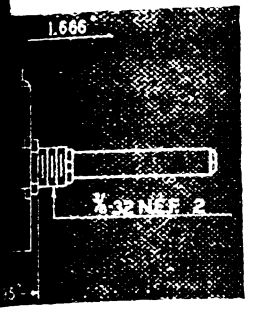

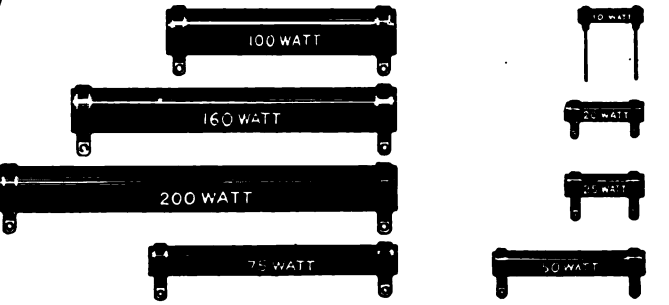

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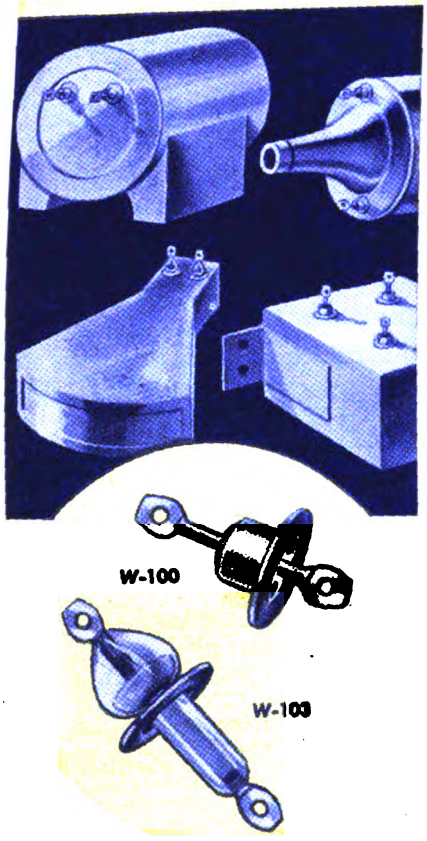

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cillator tube are used in opposite arms of a bridge while small thyratrons are actuated to keep the bridge balanced by rotation of the reversible motor which also varies an inductance in series with the load. The load is closely coupled to the tank circuit with all tuning done on one slope of the first hump of the resonance curves. The load circuit is never completely tuned but always presents a capacitive reactance to the tank circuit.

• • •

Electrostatic Paint Spraying and Detearing

ELECTRONIC GEAR SERVES in the power-supply section of equipment being used in the electrodepositing of sprayed paint to achieve very uniform coatings and to reduce the waste of material from that common in ordinary spraying techniques. The same equipment can be used to detear fatty edges on pieces painted by the dip process.

In the process, an electric field is set up around the article to be coated, the article itself being at ground potential. The field is established through a series of electrodes consisting of fine wires whose surface area is small relative to that of the piece of work.

These electrodes are fed rectified a-c in the form of pulsating d-c at voltages in the order of 100,000. The current does not exceed 10 ma. In any individual case it is necessary to balance the pressures and orifices of the spray equipment against such other factors as electrode spacing and conveyor speed to gain the greatest efficiency. Specifically, the objective is to correlate the inertia of the paint particle with the intensity of the electric field through which it is moving.

Technique

For a particular setup using 100 kv, the developer of the process—Harper J. Ransburg Co. of Indianapolis, follows a rule-of-thumb formula involving No. 30 copper wires suspended vertically and spaced ten to twelve inches from each other and with the entire electrode structure eleven inches from the article. Standard spray guns

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UNING

(continued)

e are used in opposite ridge while small thyra- actuated to keep the nced by rotation of the notor which also varies ce in series with the ad is closely coupled to rcuit with all tuning slope of the first hump ance curves. The load ever completely tuned resents a capacitive re- e tank circuit.

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e Paint Spraying ing

EAR SERVES in the section of equipment the electrodepositing int to achieve very gs and to reduce the rial from that com- ary spraying tech- ame equipment can ear fatty edges on by the dip process. ss, an electric field d the article to be cle itself being at l. The field is es- h a series of elec- of fine wires whose small relative to of work.

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setup using 100 f the process— g Co. of Indian- rule-of-thumb No. 30 copper vertically and e inches from the entire elec- en inches from d spray guns

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.042"	.016"	9746-042
.047"	.016"	9746-047
.053"	.016"	9746-053
.059"	.016"	9746-059
.066"	.016"	9746-066
.076"	.016"	9746-076
.085"	.016"	9746-085
.095"	.016"	9746-095
.106"	.016"	9746-106
.118"	.016"	9746-118
.133"	.016"	9746-133
.148"	.016"	9746-148
.166"	.016"	9746-166
.186"	.040"	9746- 3
.250"	.040"	9746- 4
.375"	.060"	9746- 6
.500"	.083"	9746- 8
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Amphenol's Synthetic Tubing resists oil . . . resists grease . . . resists acids and alkalies . . . extremely flexible . . . provides easy identification of wires becasue it is transparent . . . can be cut at any point . . . not subject to tearing or abrasion.

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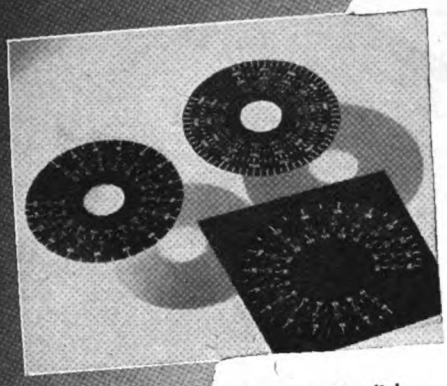

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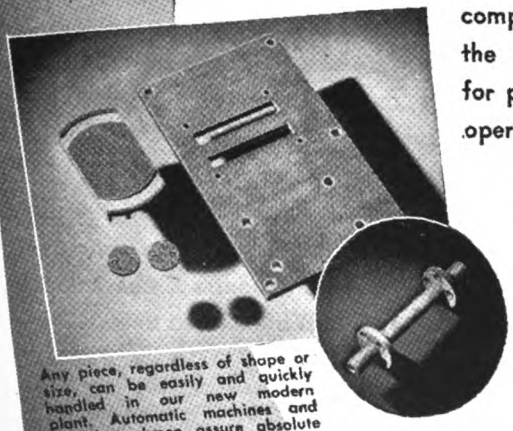

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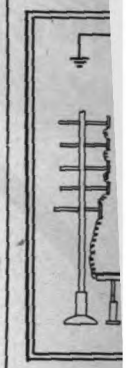

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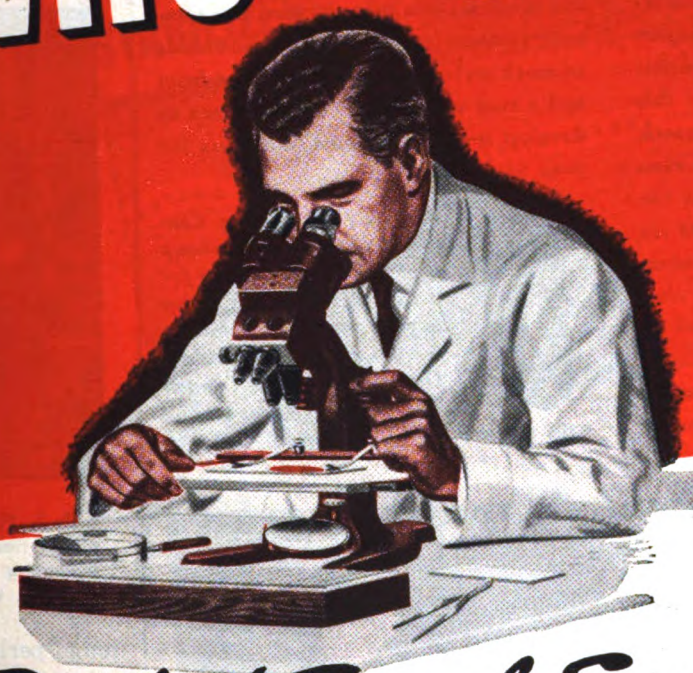

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heartbreaking anode failure during final tube performance tests. Whenever anode failure occurs in final test, hundreds of machine-hours and scores of man-hours (invested in intricate glass working and tube assembly) are forfeited at the last minute.

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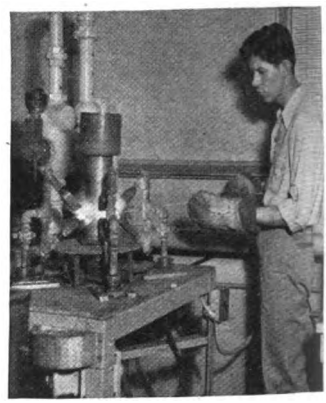

FIG. 1—Flared copper anodes of high-power transmitting tubes are joined to a seating ring by flowing silver alloy wire into the joint

long periods while cadmium or other solder is being puddled and flowed for perfect bonding of the two elements into one assembly.

Should an air pocket develop, undetected, in either joint, a localized concentration of heat in that vicinity during final tube test will cause the tube to fail.

Anode Collar Brazing Technique

In Fig. 1 is illustrated the method of joining the seating ring to the flared copper anode by flowing silver alloy wire into the joint during rotation at a temperature of 1200 F. The flared anode is set on a splined

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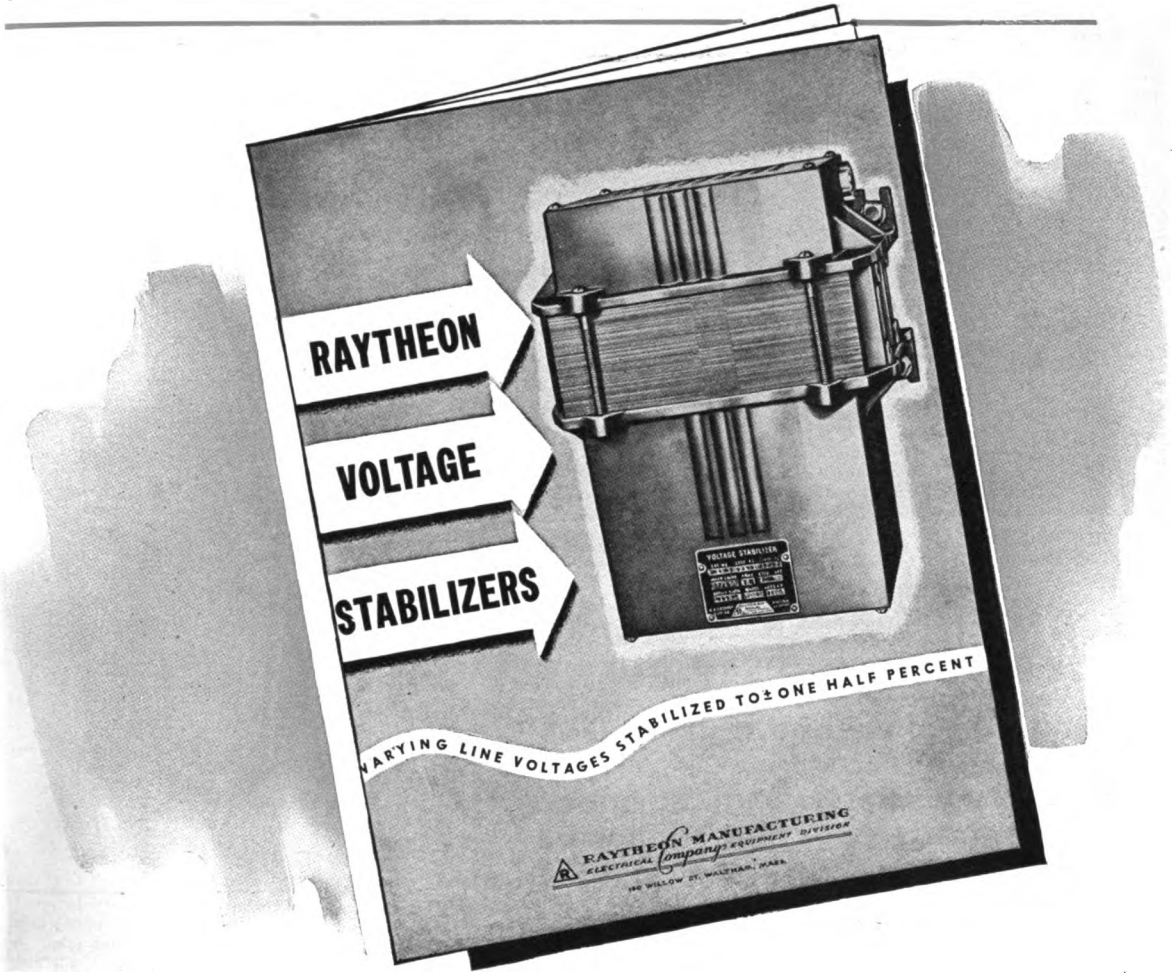

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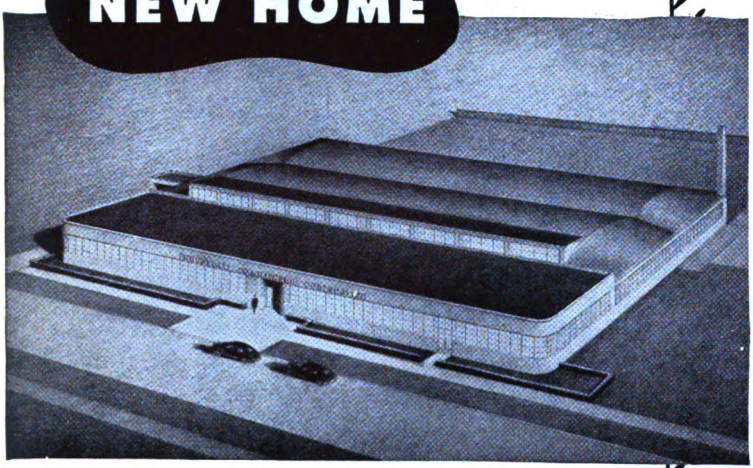

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conical spindle which rotates at 15 rpm and is constantly fed with compressed air. The air escapes between the splined conical surface of the spindle and the inside of the anode-flare, thereby cooling the thin section of the flare and localizing the heat from the gas burners solely at the joint.

Each of the eight ceramic-lined burners (which are stationary around the rotating assembly) is constructed as shown in Fig. 2. A carefully regulated mixture of gas and air is supplied under pressure to each burner, and burns from the

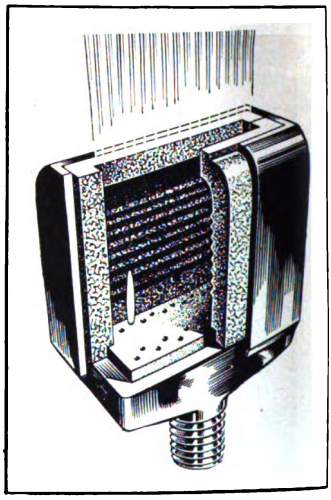

FIG. 2—Construction of a ceramic-lined burner used for heating the joint. In operation, many tiny flames issue from the ports to produce undiluted heat at the slot at top

many tiny ports in the ceramic plate deep in the interior of the ceramic cell. Thus combustion is totally confined, and the cell interior rises to white-hot temperatures. This complete surrounding of the burning gas and air with incandescent refractory surfaces tends to accelerate the combustion reaction. Consequently, only hot combustion products (undiluted by cold surrounding air) issue from the outlet slot of the burner and impinge upon the work. No flame, as such, touches anode, collar or brazing alloy.

The burners are so positioned that they fire into the joint at an angle of 45 degrees, both above and below the collar. Because of their

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close spacing to the work during the heating period, they must be racked back radially from the work for purposes of loading and unloading. The shutter-like mechanism for this withdrawal of the burners during loading and unloading can be seen at table-top level in the drawing.

Fluxing is by brush with Handyflux. Gas consumption is at a rate of approximately 130,000 Btu per hour. The gas-air supply to the burners is carbureted with air in a Selas combusion controller (of 3500 cu ft of mixture per hour capacity) which incorporates its own blade-type positive displacement compressor. Total fuel input to the

FIG. 3—Anodes for small air-cooled transmitting tubes are brazed with a smaller number of burners

burners is visually metered through a Flo-scope so that exactly reproducable combustion conditions may be assured from braze to braze.

After a braze is completed and the joint frozen, the assembly is placed in cold water, not only for cooling and flaking away excess flux, but to limit crystal growth in the copper anode.

The set-up was designed by Federal's Tube Division in cooperation with Selas Corporation of America, manufacturers of the gas-air mixing and combustion equipment involved. A similar arrangement shown in Fig. 3 is employed for the smaller size anodes.

Flexibility of both brazing tables is important because Federal manufactures no less than 75 different

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transmitter tubes from 50 watts to 200 kw in size. About eight different anode types are involved, varying in wall thickness from 0.060 to 0.500 inch. All anodes are of cold-worked oxygen-free copper, and each anode is individually checked under the metallograph for maximum grain size.

Although the primary virtue of the procedure described is that trouble-free joints are easily obtained without skilled labor and at low fuel costs, it is interesting to observe that it is now possible to complete a braze within 1½ minutes which formerly took over 20 minutes by manual oxy-gas torch methods.

Soldering Anode Into Radiator

After an anode has been brazed to its collar, machined and welded onto the glass tube, and all internal tube construction has been completed, a final bonding of the radiator fin assembly in uniform thermal and electrical contact with the entire external anode surface must be effected.

Procedure here is delicate, exacting and vital. The steps are as follows: The radiator assembly is

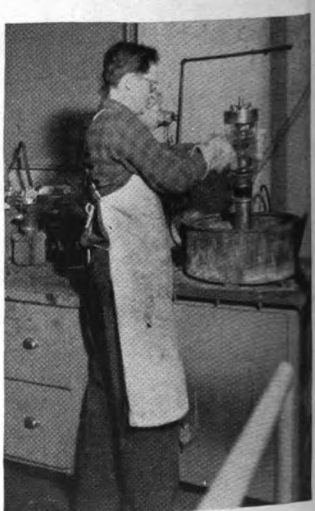

FIG. 4—Lowering the tube into the radiator assembly for soldering

lowered by chain into an empty sheet-metal pot centrally located in the small gas-fired furnace shown in Fig. 4. The pot is stepped out to larger diameter above the top surface of the furnace, thereby provid-

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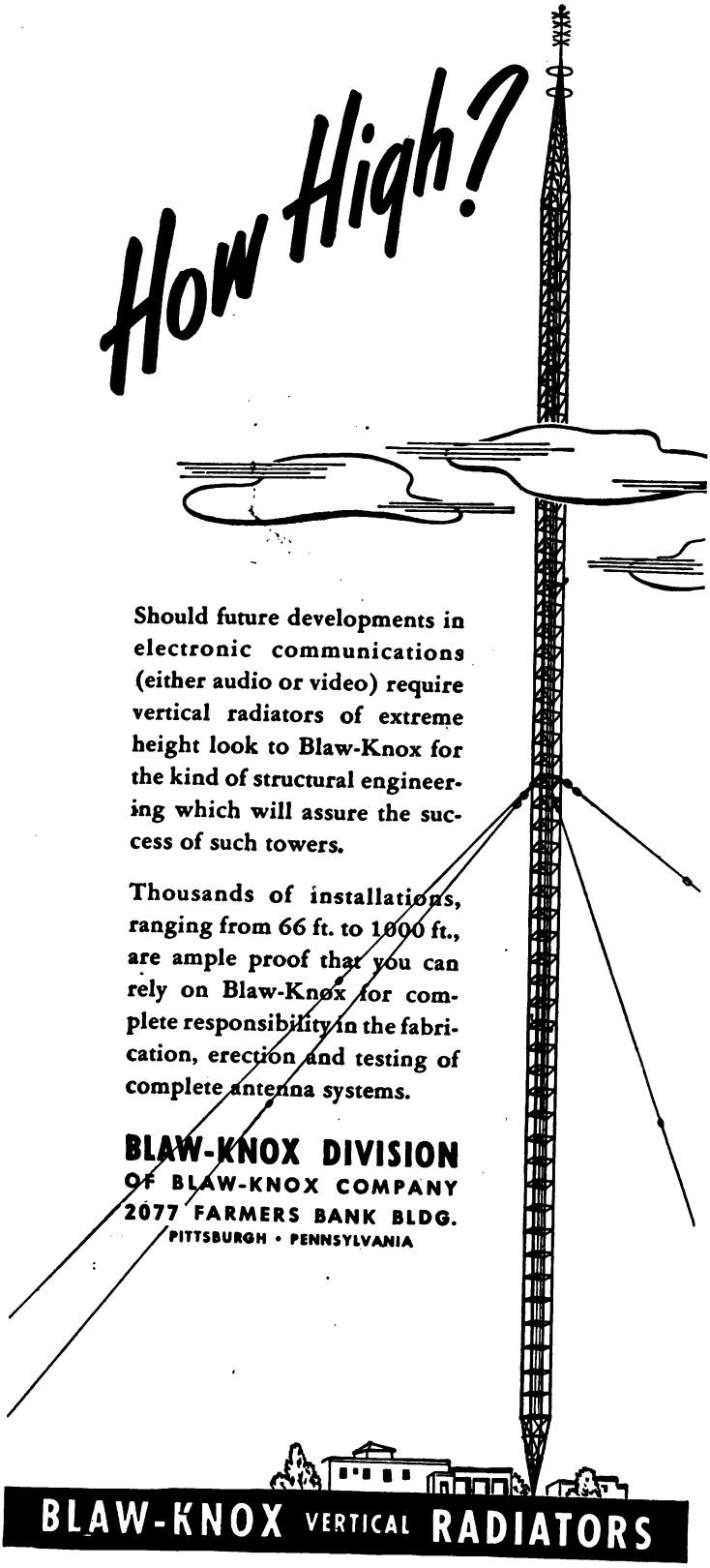

ing a ledge upon which rests a sheet metal ring for support of the radiator assembly. The pot is provided with a cover and purified-nitrogen-gas supply lines. A full hour is taken to bring the radiator slowly to heat, at which time the well within the radiator assembly is fluxed and loaded with four bars of solder. This solder melts and the anode end of the costly finished tube is slowly maneuvered down into the well. This operation is shown in Fig. 4 and 5.

It is at this point that extreme manipulative care is important (1) to prevent the entrapment of air bubbles, (2) to provide complete fluxing of both well and anode surface, and (3) to insure good wetting of all surfaces with solder. When cadmium solder is used the bonding temperature is 320 C.

FIG. 5—A weight on top of the tube maintains constant pressure to force the anode into the radiator

All in all, over 1½ hours are required after the anode has been lowered into place to flux and add approximately 1½ bars of additional solder. During this 1½ hours, weights are placed upon the top of the tube (see Fig. 5) to force the anode home. Air bubbles are caused to rise and be eliminated by working the tube with a rotary motion into the hole, and by the long period of solder flooding. After the joint is considered perfect, the furnace is

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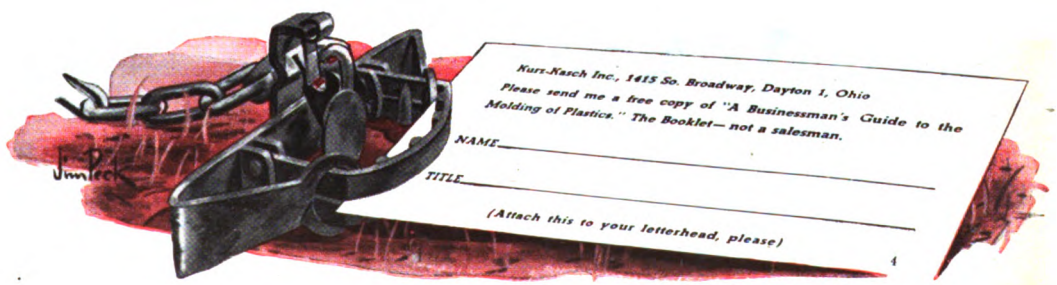

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shut off and the assembly allowed to cool and freeze slowly.

The entire sequence of operations takes about five hours. During the entire period at heat, about 20 liters per minute of purified-nitrogen-gas are forced through the space around the radiator and under the furnace pot cover. This is to minimize oxidation of the radiator fins. However, it is now felt that this protection is not sufficient to eliminate the necessity for final chemical cleaning of the radiator surface before tube shipment, and, therefore, it is intended in the future to eliminate all nitrogen purging, let corrosion take its course on the outside of the radiator-assembly, and rely on chemical cleaning entirely.

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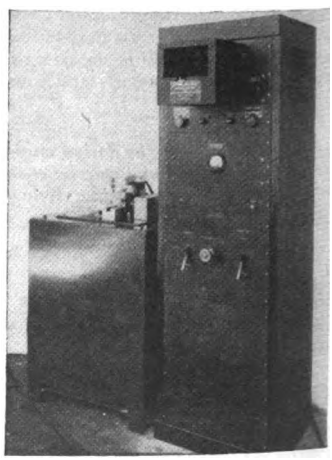

Parts to be balanced are mounted for test on the seismically suspended platform at left. The electronic equipment in the cabinet at right includes a c-r tube indicator and a phototube tachometer

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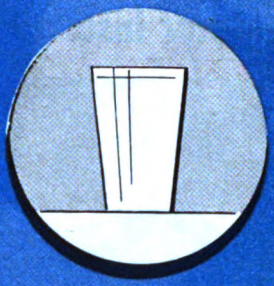

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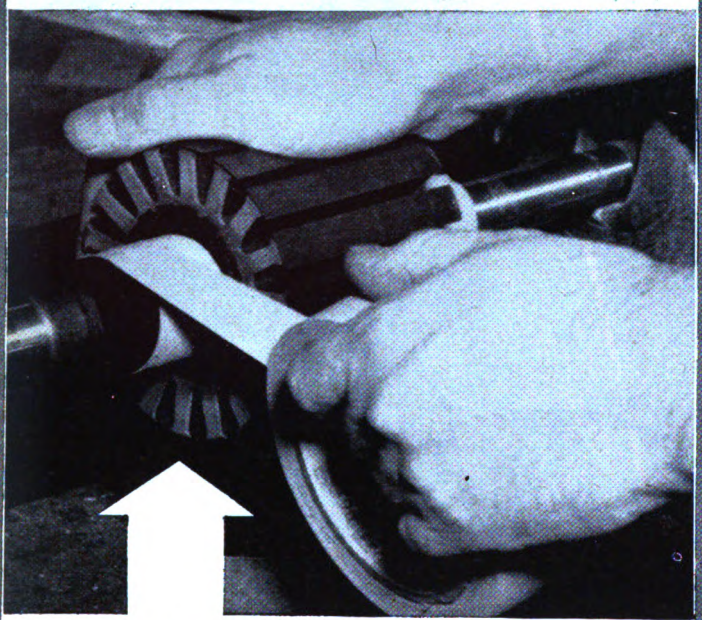

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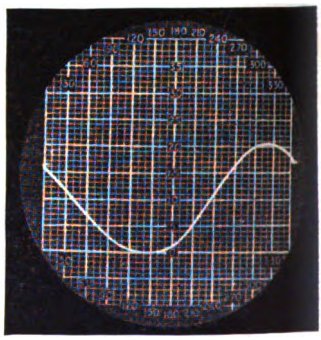

Sine-wave trace obtained on the screen of the cathode-ray tube of the Electrodynascope

through suitable electronic circuits, these voltages appear on the screen of the recessed cro tube where they can be expressed as ounce-inches or in depth of drilled or milled hole necessary for correction.

Either single-plane unbalance or that in two planes can be indicated, the planes being chosen by the positioning of the two pickup capsules into the planes where it is convenient to make the necessary corrections. Milling cutters or other correction tools can be mounted directly on the balancing platform so the rotor can be corrected and then rechecked without the necessity of its removal from the equipment.

Interpreting Trace

A typical oscilloscope trace is illustrated. It exhibits a sine-wave

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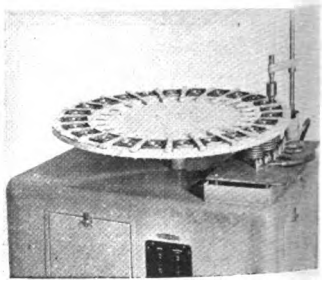
indication whose highest ordinate, in this case 20.5, represents the amount of unbalance and whose lowest peak is read on the abscissa scale as 150 deg. This reading provides the angle at which correction is to be made relative to a fixed pointer and a protractor on the driving head.

Because of the rigid mounting of the rotor, unknown inertia and dynamic forces are negligible and indications are not affected by the mass or mass distribution of the balancing table. The calibration of the unit remains constant for all weights of rotors within the capacity of the machine according to engineers of Gyro-Balance Corp., the manufacturers. Use of a cro screen for indication makes it possible to detect as distortions of the sine wave those forces which do not arise from unbalance—for instance, bearing defects.

Vibration insulation of the machines makes it possible to mount them on any kind of floor. The entire balancing platform assembly is on a heavy concrete base seismically suspended in a light outer frame, an arrangement which stops transmission of forces in both directions.

• • •

AUTOMATIC ELECTRONIC BRAZING



Used in the brazing of metal assemblies, this twenty-four-station circular indexing carrier permits the completion of one piece each twelve seconds. The operator merely loads the stations as they come around empty, ejection being performed by the vertically-operating mechanism which follows the three water-cooled induction coils. The carrier can be applied to any "S" Corrugated Quenched Gap Co. electronic generator rated between 5 and 100 kw

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PULSING DRIVE

is a small, simple, rugged device for highly accurate remote positioning and may be used with any reversible motor. It offers a precise control of the extent of motion, as well as direction of rotation, far surpassing the limits of ordinary toggle or two button switches. These units find wide application in precise tuning of radio and television transmitters and receivers as well as in diversified types of industrial equipment.

CONTINUOUSLY VARIABLE CONTROLS

provides a means of continuously positioning a remote load through one or many revolutions. The load may be moved forward, backward or stopped in any position with high accuracy. Any movement of the control knob results in a corresponding movement of the load. Types available include synchronous, non-synchronous, low or high torque with or without automatic scanning. Accuracy to 1/100 of a degree is possible.

SPOT TUNER

makes it possible to rotate a remote shaft to any one of six to ten predetermined positions. Push button selection is provided for each position. All positions are easily and quickly adjustable to any point within the 180° control range. This system is particularly applicable to high precision tuning of radio and television equipment. Accuracies to one part in 18,000 are entirely feasible.

MULTI-REVOLUTION SELECTORS

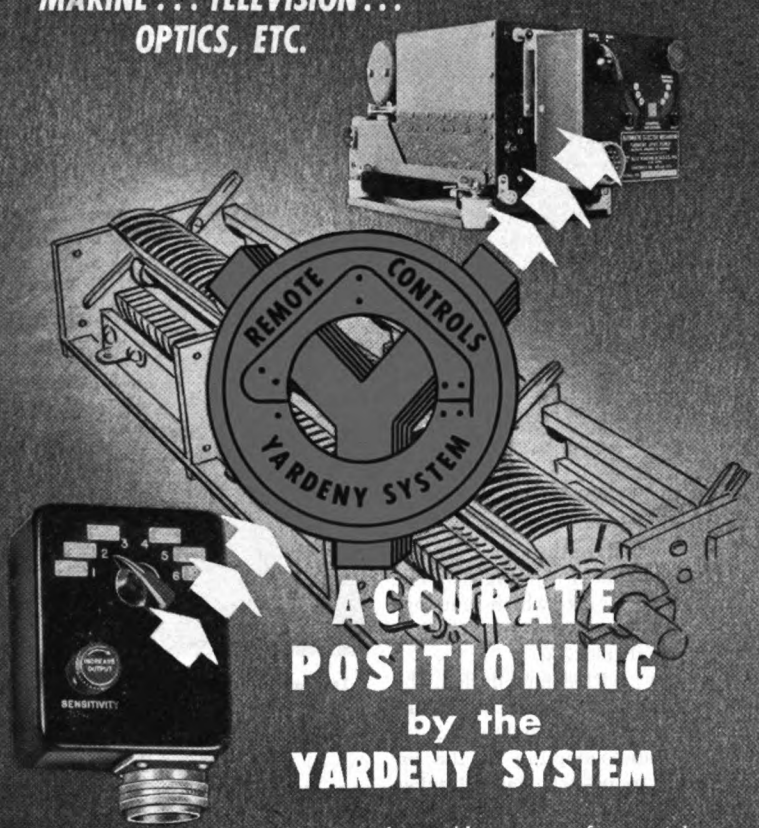
remotely rotate a load to any one of several spots through from one to a number of revolutions. Push buttons are provided for all positions. Positions are easily adjustable to any desired location through the range of the unit. These controls permit extreme accuracy in positioning the load. Accuracies to one part in 1,000,000 are not uncommon.

DUAL CONTROLS

combine the features of the continuously variable control with those of the automatic selectors. The control head is provided with a knob for continuous positioning of the load. Any movement of the knob is followed by a corresponding movement of the load. In addition, a bank of push buttons permits automatic positioning of the load to a number of preset locations. These load positions may be easily adjusted and re-located to any point within the range of rotation.

MISCELLANEOUS

YARDENY devices include those for many other applications, one or more of which may solve your specific requirements.



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YARDENY precision remote controls provide a means of accurately positioning or moving a load which is remotely located from the operator. Positioning accuracies as high as one part in a million are attained. Although this remarkable accuracy is an outstanding feature of YARDENY controls, they are simple, rugged and dependable. All are practically immune to temperature change, extreme shock, vibration or severe usage—with dependability proved through extensive use by the Armed Forces.

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TUBES AT WORK

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Piggieback Transceiver 414
Audio Design for Battery-Powered Receivers 418
Modulated-Air Super Speaker 426

Pulse Modulation in Army Equipment

AT A RECENT DEMONSTRATION staged by Signal Corps Engineering Laboratories, two equipments shown used pulse-position modulation, a new method of modulation whose war-time application has been kept secret. One of these, radio set AN/TRC-6, is the first practical tactical radio equipment of this type developed.

To obtain a multi-channel radio relay system for the Army, it was necessary to use telephone terminal equipment. When development of the AN/TRC-6 was undertaken in 1943 it was decided to include in the equipment the multi-channel facilities desired, but without the use of extra telephone equipment. The result was a set which employs pulse-position modulation with time division multiplexing.

In pulse-position modulation, the pulse which transmits the intelligence repeats at a regular rate so that periodic sampling of the intelligence to be transmitted takes place. When the intelligence is applied, the pulse's time of occurrence is correspondingly varied in position and time.

In radio set AN/TRC-6, eight separate pulses are used and the time of occurrence of each is varied in accordance with the intelligence transmitted from one of eight separate channels. No two pulses are allowed to occur at the same time, they are interlaced. Thus, eight telephone circuits are available for simultaneous use. Each of these may be connected to conventional telephone lines. If desired, as many as ninety-six telegraph circuits can be substituted for the eight telephone circuits available.

According to the Army, radio set AN/TRC-6 provides transmission which is as quiet and distortionless as the best commercial telephone circuits available, and it is subject to very little static or atmospheric disturbance because of its use of pulse modulation and the choice of radio frequency.

Transmitting and receiving antennas of the Army radio set AN/TRC-5, the 1,400-mc multi-channel equipment using pulse-position modulation, are raised with the help of a jury mast. The 4,900-mc antennas of the AN/TRC-6 ppm set appear at center.—U. S. Army Signal Corps photo

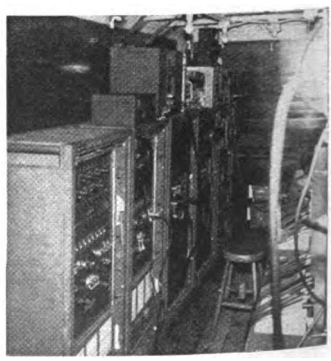
The AN/TRC-6 operates in the frequency range between 4,300 and 4,900 megacycles. The equipment is usually carried in a 2½-ton truck. Because of its size and complexity the equipment is not intended for use in forward areas but is used between armies and army groups and from army groups to rear areas.

Used In Europe

The equipment was introduced into the European theater in December 1944. When more equipment arrived in April, circuits were installed between several army groups. As the Third Army advanced into Germany constant communications between it and the 12th Army Group were maintained over nearly 300 miles, using two terminals and three relay stations.

In the Pacific, radio set AN/TRC-6 has seen only limited use in Hawaii, but it is expected that a number of these sets will be used in the occupation zones.

A second set, the AN/TRC-5, performs functions identical to those of the AN/TRC-6 but operates at



Operating setup of the AN/TRC-6 ppm multi-channel relay station for frequencies between 4,300 and 4,900 mc—U. S. Army Signal Corps photo

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In medieval times discriminating knights journeyed to Toledo, Spain, to obtain hand-wrought blades of steel.

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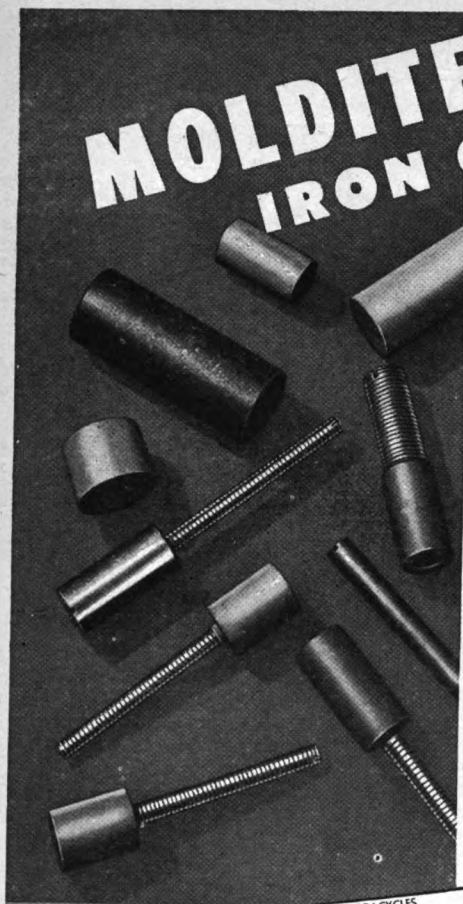

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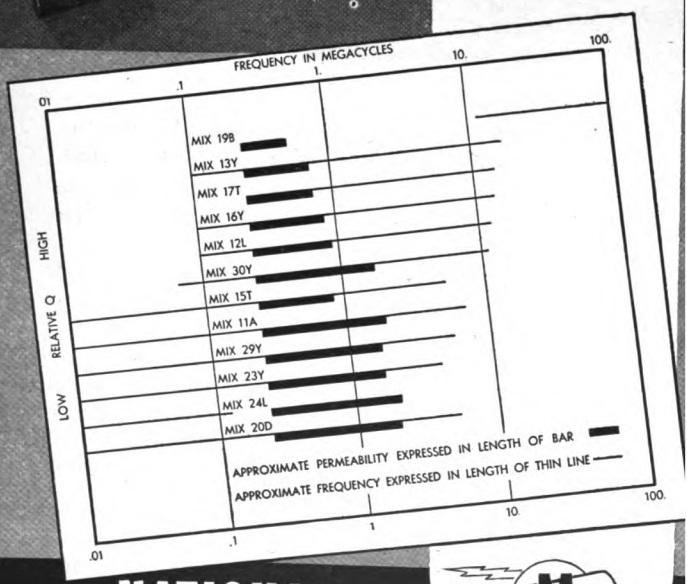

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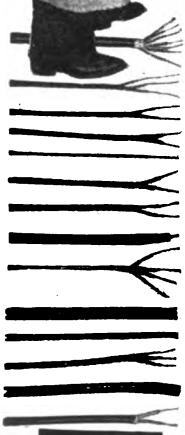

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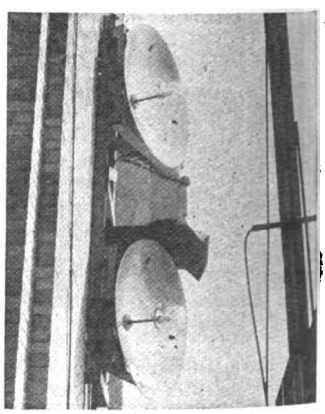
rate corresponding to the audio frequency of the signal being broadcast.

Since the transmitted wave is intermittent and not continuous, it is possible to operate the transmitter and adjacent receiver at the same frequency by including suitable time-delay circuits in the receiver and by making it insensitive while the transmitter pulse is being emitted.

Sequence of Pulses

The present system uses a single marker pulse followed by 24 signal-pulses for the 24 channels, the entire sequence being repeated at a rate of 8,000 pps. Without modulation, the entire 25 pulses are evenly spaced in time. If a signal is applied to Channel No. 1, the No. 1 signal pulse will occur slightly sooner or later in the first sequence cycle than its no-signal position. The bandwidth now in use is 3 mc.

The marker pulse synchronizes the receiver with the transmitter,



Antennas for receiving and transmitting ptm signals on 1200 megacycles are installed on the IT&T Corp. building at 67 Broad Street, New York City

so that the receiver will examine the input on each of the 24 channels in sequence, at the same rate of speed and repetition as the transmitter. Each audio channel is actually sampled or interrupted 8,000 times per second, but these interruptions occur at such high speed that they are not audible to the listener.

Requirements for the design of pulse-time modulation relay stations are much less critical than for

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ACTUAL SIZE

The old quill was picturesque but it lacked the compactness, convenience and dependability of our modern fountain pen. Its development was the usual evolution. Changes and reduction in size made for greater efficiency. The same took place in the development of the modern miniature electronic tube.

While the reduced size of TUNG-SOL Miniatures alone warrants a preference for them, their greater efficiency has resulted in their general adoption, especially for high frequency circuits. Smaller elements make them more rigid. Shorter leads result in lower lead inductance. TUNG-SOL Miniatures have low capacity and high mutual conductance.

The TUNG-SOL interest in electronics is the development and production of more efficient electronic tubes. Equipment manufacturers are invited to consult with TUNG-SOL engineers on problems of circuit planning and tube selection. Consultation is always confidential.

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other methods of modulation since only the spacing of the pulses is important. The pulse shape need not be exactly reproduced and this permits most of the tube noise to be eliminated merely by clipping the bottoms and peaks of the received pulses. Cross-talk from adjacent channels is completely eliminated because only one channel is actually on the air at one time. Another advantage of the system is the fact that telephone dialing and bell-ringing operations can be easily effected since it is feasible to transmit direct current for these functions without additional equipment.

Cyclophon Provides Electronic Switching

Placing of 24 two-way voice channels on a single carrier is accomplished by a new cathode-ray tube called a cyclophon, which rotates a cathode-ray beam in sequence to each of 24 dynodes that feed the 24 channels. The beam makes 8,000 complete revolutions per second, with the result that signals forming the sound are put into receivers so fast that the human ear cannot distinguish any intervals between them, thereby making for exact duplication of speech or music.

The electronic time selection devices at both the sending and the receiving stations operate in perfect unison to avoid cross-talk and other confusion. This is accomplished by transmission of a synchronization pulse at the beginning of each cycle so both time selection devices start off together.

The stations both send and receive, changing from one to the other with lightning speed. So rapid are the changeovers effected that they are not noticeable in a two-way telephone conversation, even if the two parties talk at the same time. Each vibration of the vocal cords is transmitted as 6 to 12 separate pulses, with the tube circuits and the human ear together filling in the gaps between pulses at the receiving end. The audible results which ptm present to the ear can be compared with visual effects which the motion picture presents to the eye. Although the screen in a motion picture theater

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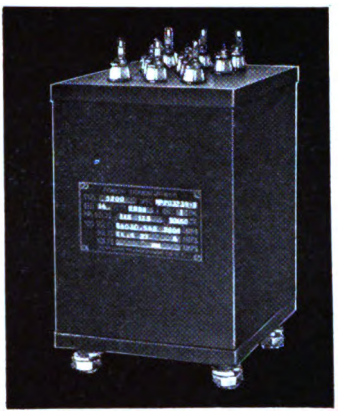

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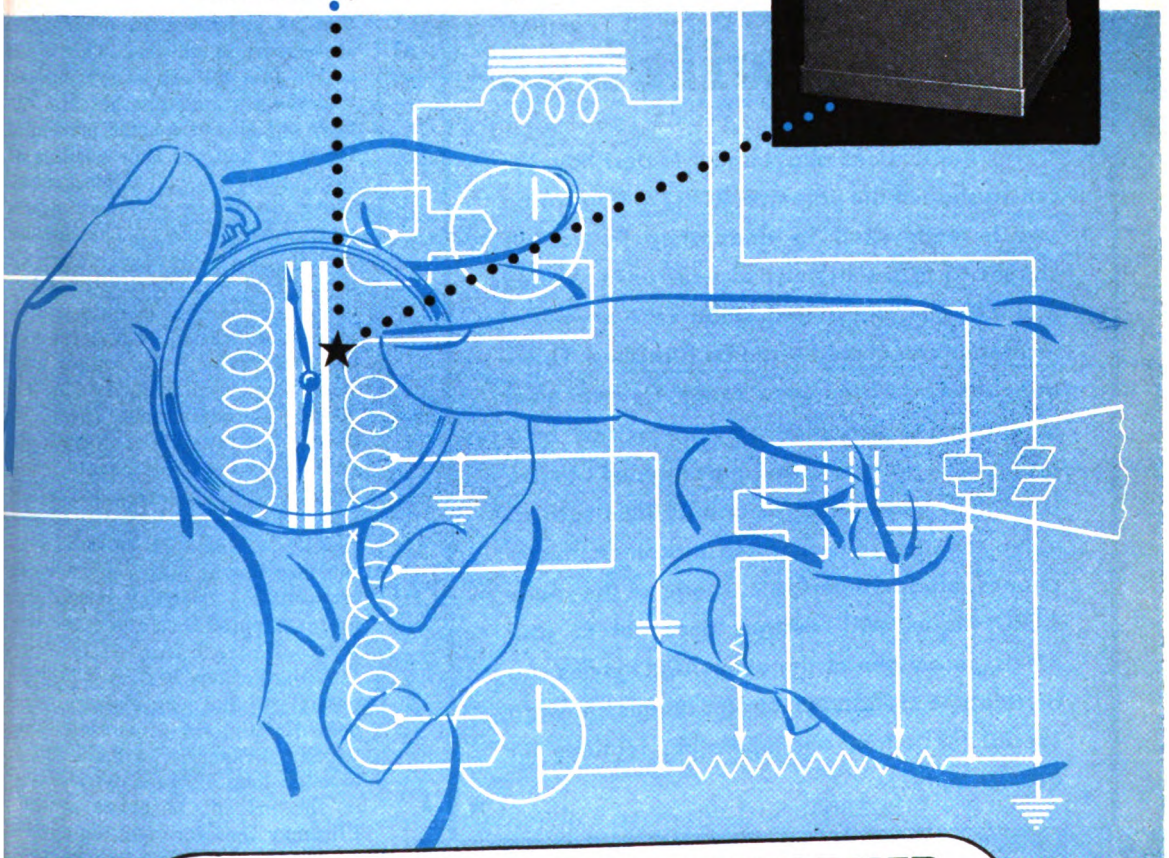

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is completely dark much of the time that a film is being shown, the eye is not quick enough to detect the dark intervals.

The present system is the logical outgrowth of the pioneering efforts of the I.T.&T. companies, dating back to 1931 with the Dover-Calais microwave communication system and the first multi-channel voice communication circuits between Scotland and Ireland. The entire sending apparatus can be made to occupy a cabinet only three feet high and covering a floor space 20 inches square, and containing fewer tubes than the average home radio. The receiver cabinet is similar in size and number of tubes.

Advantages and Applications

A special advantage claimed for ptm is the reduction of static, crosstalk and other noises in the reception as compared to other radio systems—a-m and f-m. This is due to the fact that these systems use the whole radio wave but ptm can filter out all but a small portion of the wave and the time position of the pulses remains unchanged. Wave distortion therefore has a much smaller effect. This feature permits the widespread use of repeater stations, where a transmission is picked up and retransmitted to another station. The noise does not accumulate in the relayed message. The repeater stations are required approximately every 30 miles, but operate automatically and require no attendants. The clarity of reception obtained is valuable in radio and television broadcasting. Of especial significance is the fact that it makes possible the transmission of many music programs simultaneously over the system.

With the new system it will be possible to dial long distance numbers directly, say from New York to San Francisco, without going through long distance operators as in the present telephone system. Ptm may therefore find use advantageously in radio-telephone systems for railroads, taxi companies, etc—in fact, any application where multi-channel operation, versatility, and clarity of reception are desired.

The ptm system is also applicable

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Watts, Nominal	1/25	1/25	③	¼	¼	¼	1	1	2	2	3	3
Volts (Circuit)	105-125	105-125	③	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Starting Voltage ① AC	65	65	③	65	—	65	60	60	60	60	60	60
Starting Voltage ① DC	90	90		90	⑤	90	65	65	65	65	65	65
Base	★Unbased (Wire Terminals)	★S. C. Bay. Min.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	Cand. Screw	Medium Screw	★D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.
Maximum Overall Length	② 1¼"	1⅜"	1½"	1½"	1½"	1⅝"	2⅛"	2"	3⅝"	3¾"	3⅝"	3¾"
List Price (plus tax)	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

① Applies to lamp when new.
② Glass part; wire terminals extend additional 13/16".
③ Designed for DC flashing operation in RC circuit.
④ Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
⑤ Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).
★ All Bayonet Base Lamps Need External Resistance.

For further information, write address below for Bulletin 7100

NELA SPECIALTY DIVISION, LAMP DEPARTMENT

GENERAL ELECTRIC

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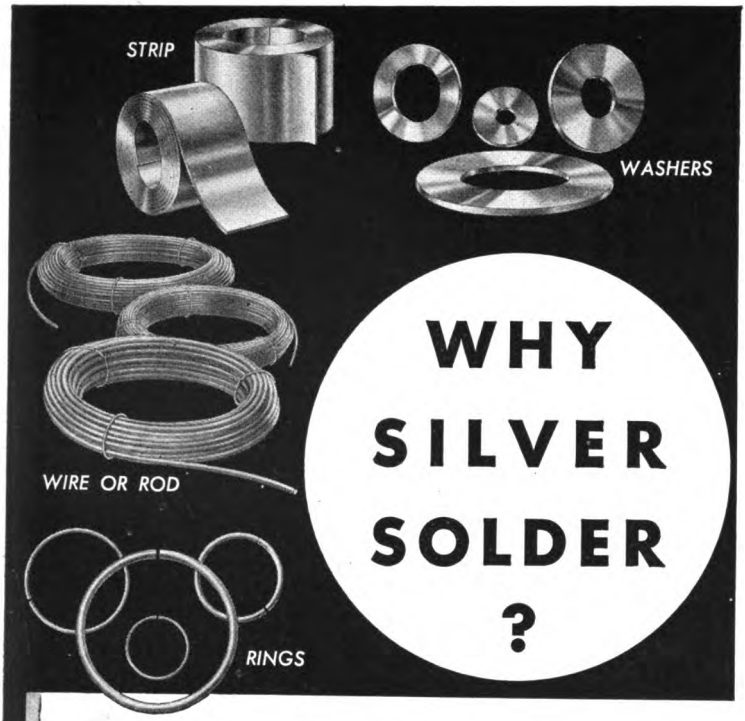

WHY SILVER SOLDER ?

Silver soldering, because of its speed, economy, and durability has replaced for many purposes former methods of soft soldering, high temperature brazing, welding, riveting or bolting. Cast and forged constructions, in many instances, have been replaced by the faster and less expensive method of fabricating two or more easily joined parts, soldering them together, then finishing to dimension.

Modern alloys and light gauge metals, likely to be damaged by high temperature brazing or welding, have been particularly aided by the use of low temperature, fast spreading silver solder. Likewise, the use of preformed rings or washers has materially speeded up straight line production.

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To help you with any problems which you may have, we maintain a fully equipped research and testing laboratory as well as a staff of thoroughly experienced metallurgists, chemists and consultants who will be pleased to assist you with any problem you may have to the full extent of their facilities and ability. Your inquiries are cordially invited.

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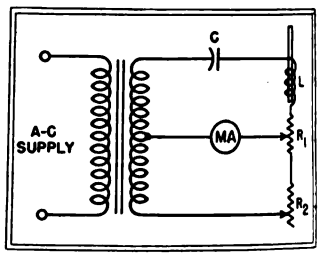
to the transmission of color television with sound on the same channel. If used for radio broadcasting, it would make possible the simultaneous transmission of twelve different programs from the same station.

• • •

Testing Coils for Shorted Turns

A SIMPLE and useful instrument for the rapid testing of coils is shown in the accompanying schematic. Reactance of the search coil L is balanced by capacitance C. Exact balance of the bridge is obtained with the resistor R_2; resistor R_1 being in the mid position.

The instrument is then adjusted for a-c supply by varying R_1 until a standard reading is obtained on



Circuit of simple coil testing unit capable of detecting a single shorted turn of 40-gage copper wire. The coil is placed over projecting core of inductor L

the rectifier-type milliammeter MA. The coil to be tested is placed over the projecting iron core of the search coil and if short-circuited turns are present the normal deflection of the meter will change.

It is claimed by the designers that a single short-circuited turn of 40-gage copper wire can be detected. This is an extreme case since in most bad windings two or more layers are shorted, hence there is usually considerable deflection. The tester is produced by Banner Electric Co., Hoddesdon, Hertfordshire, England.

• • •

Electronic Antenna-Analyzer

MATHEMATICAL COMPUTATIONS involved in the location and arrange-

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THE TWO CHANNEL PHASE-SHIFT MODULATOR IS STILL THE BEST

REL is the pioneer builder of the phase-shift modulators and transmitters for the Armstrong wide band FM system of radio signaling. The modulators include the original design and the greatly improved two channel design described by Major Armstreng before the Institute of Radio Engineers on Nov. 5, 1941. Modulators built by this company have been in constant reliable operation throughout the country since 1938. And on Mt. Washington, inaccessible for months each year, the two channel modulator has performed without a flaw.

The basic electrical characteristics of the two channel modulator now in the field leave little oppertunity for improvement but we have learned how to add to the modulators reliability through improvements in its mechanical and compenent design. REL takes pride in announcing that the improvements are substantial and that they are incorporated in REL FM broadcasting transmitters shortly to be made available to the industry.

REL

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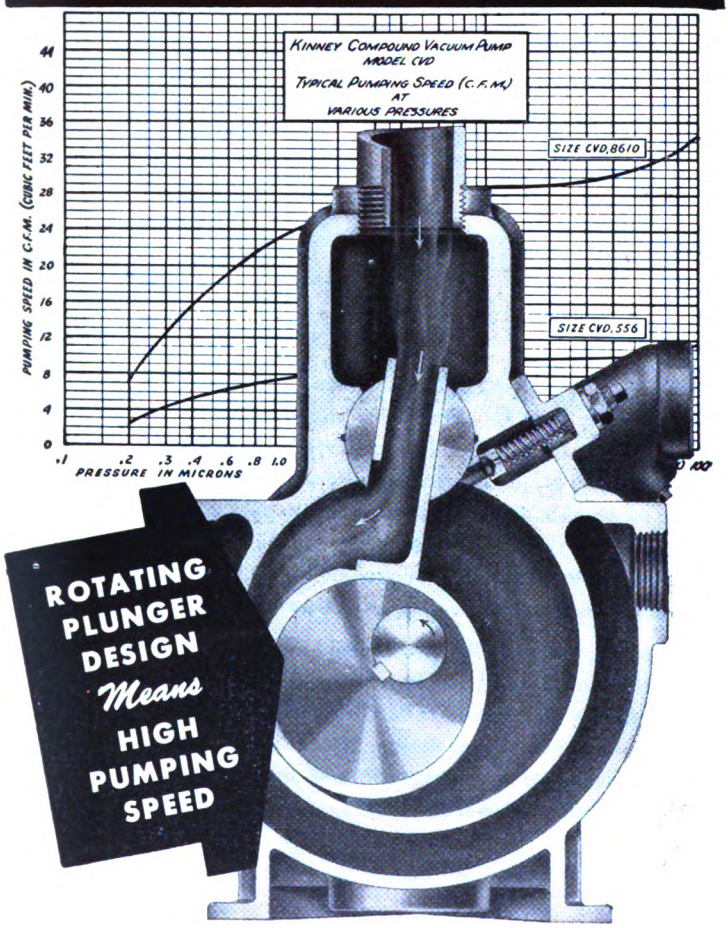

The design of Kinney High Vacuum Pumps has been proved by years of actual performances; today in over 10,000 installations, Kinney Pumps are producing low absolute pressures rapidly and dependably.

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ment of directional-antenna towers are quickly performed by the Antennalyzer, a new piece of computing equipment developed at RCA Laboratories and shown in operation in Fig. 1.

Using 52 electron tubes, the gear

Fig. 1—An RCA technician manipulates the controls of the Antennalyzer which solves the mathematics of directional antenna-array design

is adjusted until the pattern on a c-r screen reproduces the desired field of the projected transmitter. Corresponding dial readings provide data on the location of towers and give all the electrical parameters connected with the overall design of the array.

A rear view of the equipment is shown in Fig. 2. Mathematically, its operation in the case of a five tower array depends on solution of the equation

$$F = KI_A \sqrt{\begin{aligned}&\Big\{1 + M_B \cos\left(\alpha_B + \tfrac{2\pi d_B}{\lambda} \cos\left[\phi - \theta_B\right]\right)\\ &+ M_C \cos\left(\alpha_C + \tfrac{2\pi d_C}{\lambda} \cos\left[\phi - \theta_C\right]\right)\\ &+ M_D \cos\left(\alpha_D + \tfrac{2\pi d_D}{\lambda} \cos\left[\phi - \theta_D\right]\right)\\ &+ M_E \cos\left(\alpha_E + \tfrac{2\pi d_E}{\lambda} \cos\left[\phi - \theta_E\right]\right)\Big\}^2\\ &+ \Big\{M_B \sin\left(\alpha_B + \tfrac{2\pi d_B}{\lambda} \cos\left[\phi - \theta_B\right]\right)\\ &+ M_C \sin\left(\alpha_C + \tfrac{2\pi d_C}{\lambda} \cos\left[\phi - \theta_C\right]\right)\\ &+ M_D \sin\left(\alpha_D + \tfrac{2\pi d_D}{\lambda} \cos\left[\phi - \theta_D\right]\right)\\ &+ M_E \sin\left(\alpha_E + \tfrac{2\pi d_E}{\lambda} \cos\left[\phi - \theta_E\right]\right)\Big\}^2\end{aligned}}$$

where F is field strength in direction of angle ϕ, M is current ratio in each tower relative to tower A, α is phase angle of each tower current, d is spacing from a reference point of each tower, λ is frequency of transmission, ϕ is angle whose function is used to plot field

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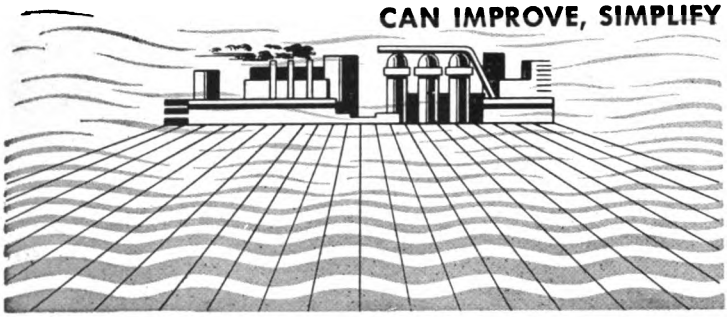

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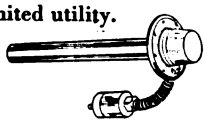

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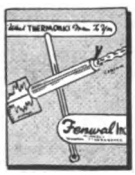

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strength of system, θ is azimuth angle of each tower with respect to a reference line.

Field tests and calculations which formerly required weeks can now be executed in a matter of minutes. The Antennalyzer adds and subtracts angles, looks up trigonometric functions, adds numbers, squares them, and ends by taking the square root. Radiation patterns can be converted from rectangular to polar coordinates at the flick of a switch.

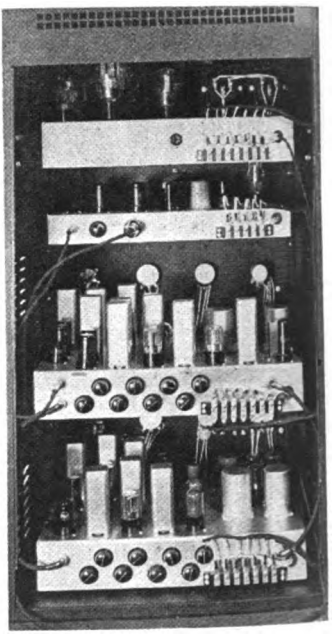

Fig. 2—Rear view of analyzer. Entire gear includes 52 electron tubes, reduces work of weeks to a few minutes

• • •

German Magnetic-Tape Recorder

USING TISSUE-THIN plastic-base tape impregnated with iron oxide, a recording and playback unit developed in Germany has a flat frequency response from 50 to 8000 cps with only a slight falling-off up to 12,000. Manufactured by the E. E. G. Magnetophon Co., the device was reported by *Broadcasting*.

Recording tape costs three dollars a roll and runs for about twenty minutes. The material is

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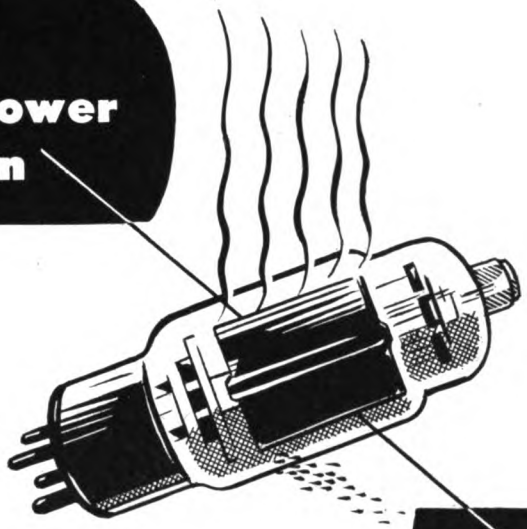
4 TIMES greater power dissipation



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- MATERIAL "A" . . . 16 WATTS
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(based on comparison at 510°C)

How much power will a transmitting or rectifying tube safely handle? That largely depends on the ability of the anodes to dissipate the heat of operation. And *that* in turn depends on the anode material.

Tubes with SPEER Graphite Anodes, tested at the temperature at which all anodes begin to show red color, dissipated 70 watts—a dissipating value *4 times higher* than the average of two other widely used anode materials tested in identical tubes. SPEER Graphite Anodes rated *3½ times better* than the second best material. This greater heat dissipating value of SPEER Graphite Anodes greatly lessens the possibility of tube damage due to warping and fusing.

Graphite's native properties, and the manufacturing techniques that give SPEER Graphite Anodes their high radiating emissivity and high thermal conductivity, also effect the other advantages listed at right. Whether you make or use tubes, if they have SPEER Graphite Anodes—you can count on consistently uniform performance *throughout life* of your tubes. Write for details now.

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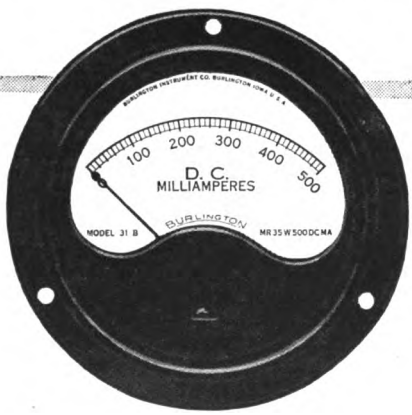

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manufactured by I. G. Farben. Three heads are used on the machine, one for erasing, one for recording, and one for playback. In the rare case of tape breakage, repairs are quickly made with a chemical supplied for the purpose.

American engineers who have checked the gear indicate that it excels conventional recordings in dynamic range, absence of noise, and ease of editing as well as frequency response. Life seems unlimited, some of the recordings having been used at Radio Luxembourg since 1941 with no sign of deterioration.

• • •

Crystal Oven Anticipates Temperature Changes

CAPABLE OF UNDERGOING the rigorous conditions of military service from the points of view of temperature range and rough service, a new thermally regulated quartz crystal oven has been designed for airborne radio equipment by engineers of Federal Telephone and Radio Corp. In operation, it actually anticipates changes in ambient temperature before they reach the crystal. Basically, it consists of an inner Bakelite chamber to hold the crystals, an insulating air chamber surrounding the Bakelite one and containing heating coils and a limiting thermostat, and an outside Bakelite cover. The unit is 1⅞ in. square and 2⅛ in. high, including the standard 11-pin base upon which it is mounted. It holds one to three plated type of crystals or one or two of the pressure-mounted type, yet it occupies about one-fifth the space required for the previously manufactured ovens.

The working parts of the oven are as shown in the cutaway drawing. The inside Bakelite chamber *A* holds the crystals *B*, and is surrounded by a casing *C* of conductive material. An air space *D* surrounds this chamber and acts as an insulator between the outside atmosphere and that of the chamber *A*, since the temperature of the air in *D* is raised or lowered by the thermostatically controlled heater *E*. The thermostat *F* is of the bimetal type which closes on lowered temperature and is usually adjusted to

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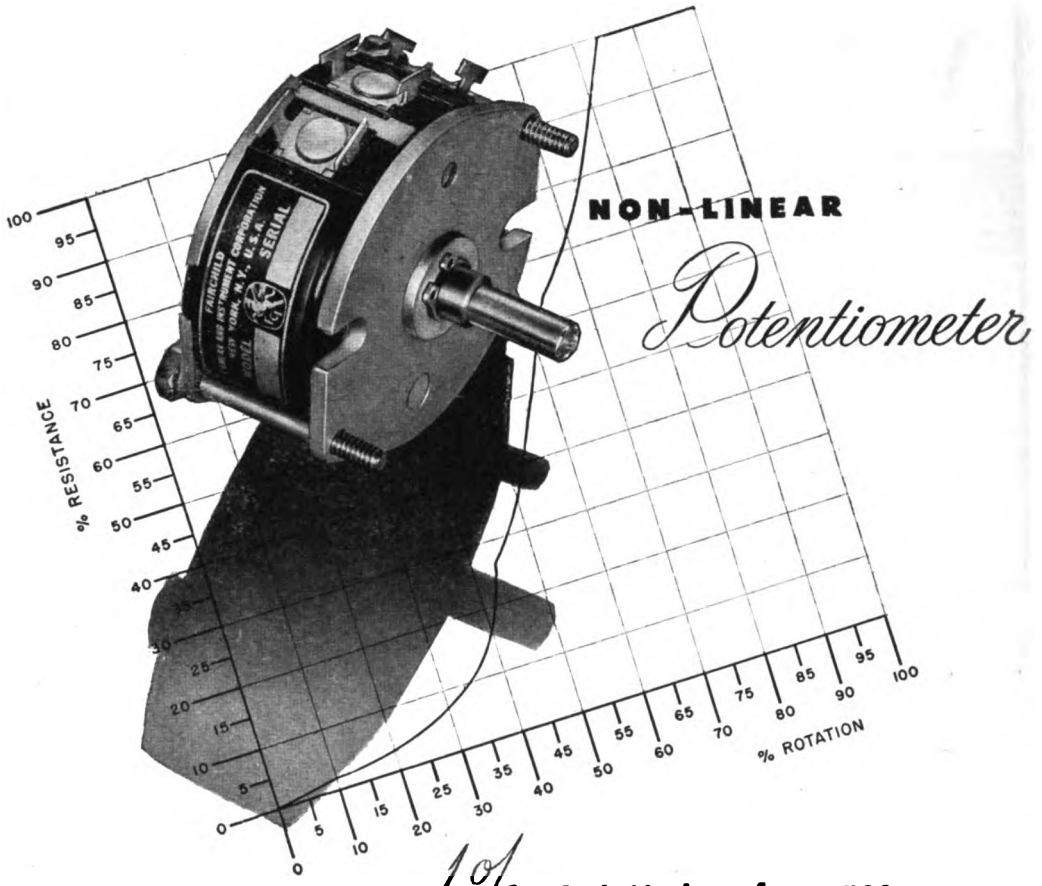
INSTRUMENTS – *precisionized* – mechanically and electronically – *for finer performance*



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Industry is now offered the full advantages of this war-time development. It eliminates intricate, space-consuming, expensive mechanical cams and linkages and electrical units—used with or without linear potentiometers.

Fairchild's *non-linear* Potentiometer offers these excellent design possibilities: Small size—being 1⅝" in diameter, $\frac{33}{32}$" thick, with shaft diameter optional, but usually ¼"... high 'linearity' —ability to follow a plotted curve of resistance versus rotation within an error of 1% or less at any point on the curve ... great flexibility for reproducing almost any desired curve.

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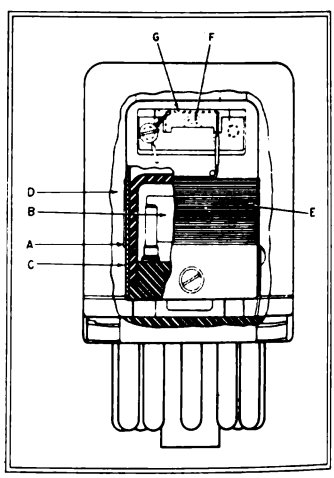
a temperature of approximately 75 C.

An important feature of the oven is the trigger wire *G* placed in close proximity to the thermostat and connected in series with the heater. This wire raises the temperature of the thermostat as the heater is turned on, causing the thermostat to open without waiting for the heat to be conducted to the thermostat through the air space *D*. Such action prevents overshooting and makes for uniform temperature in the air space *D*.

Anticipating Action

Operation of the thermostat is an intermittent opening and closing of the switch, producing heat pulses in the main heater *E*. The pulses range from 10 per minute at minus 40 C to 1 per minute at plus 70 C. By this type of pulsating action, air



Cutaway view of the crystal oven for aircraft radio equipment that anticipates temperature changes

in the insulating chamber *D* is more rapidly heated whenever the ambient temperature drops and conversely it is less rapidly heated when the ambient rises, thus acting upon the insulating air in such a manner that temperature changes are anticipated before they reach the oven.

The oven is designed to operate over an ambient temperature range of minus 40 C to plus 70 C with the frequency drift not exceeding plus or minus 0.001 percent. At five

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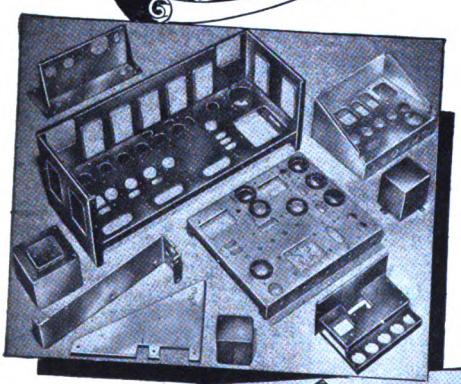

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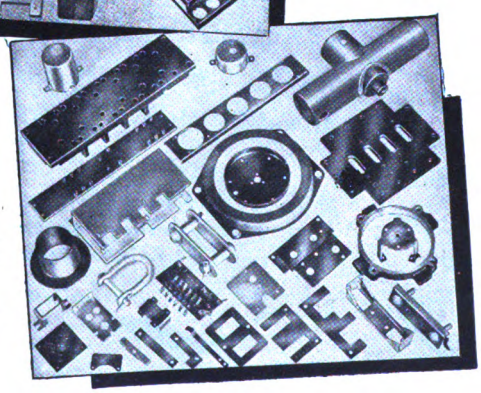

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megacycles this would mean plus or minus 50 cycles, and with properly cut crystals the oven will operate to considerably less than half this tolerance. The actual total temperature deviation of the oven is one degree, and the temperature swing at any one ambient does not exceed three degrees.

The heater was designed to operate on 24 volts a-c or d-c. However, it was found that the oven is efficient at lower voltages when the temperature range is limited to a point where the heater will not operate continuously. Power consumption varies from one watt at 6 volts to approximately 14 watts at 24 volts. From five to eight minutes are required to enable a cold oven at minus 40 C to warm up sufficiently to provide stabilized frequency.

• • •

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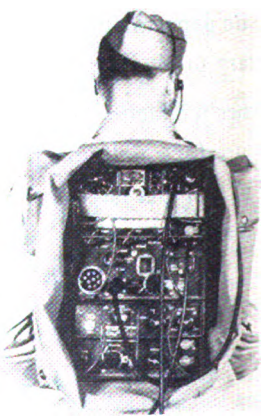
ORIGINALLY DEVELOPED as a small receiver - transmitter combination for airborne troops, the SCR 694, as illustrated, is credited with being one of the most versatile units



Twenty pounds of transmitter-receiver in the single case of model SCR 694. At the right is the battery pocket, jumper-connected. With cover in place, the set is watertight enough to float without damage

ever sponsored by the Army Signal Corps. Infantry, artillery, amphibious, and Navy forces have found useful tasks for it as well.

The receiver is a sensitive 6-tube

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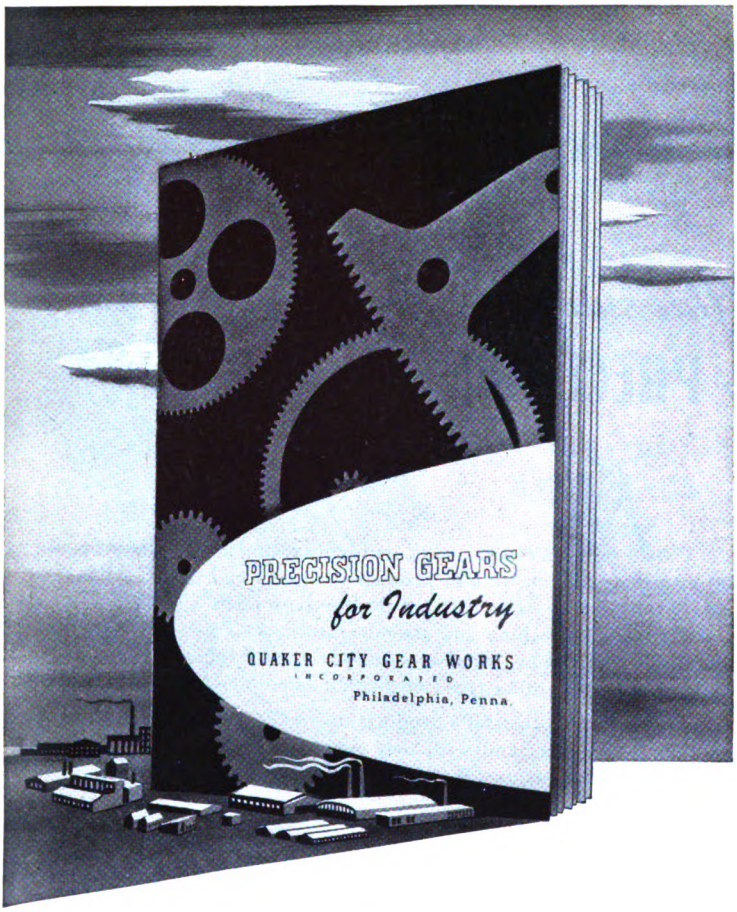

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unit that operates a loudspeaker. It has a built-in calibration oscillator which supplies a standard for tuning, and a netting control which facilitates adjusting both the transmitter and receiver to exactly the same frequency. A sensitivity control allows operation of the receiver near another transmitter without blocking. Both the receiver and transmitter operate on a-m signals and cover a frequency range of 3.8 to 6.5 mc.

The radio units, without the panel cover, are moistureproof and fungusproof, being, therefore, extremely efficient and stable for use in tropical climates.

For vehicular operation the radio is powered by a vibrator supply which functions from a 6-, 12-, or 24-volt source. This feature affords flexibility, which allows the radio to be installed in motor vehicles, tanks, and planes. For field use the radio is powered by a new type of hand generator with chain drive.

The transmitter provides phone, cw or mcw operation. It has a power output of 25 watts, an approximate range of 65 miles with a whip antenna in a vehicle, and a range of several hundred miles when a long wire antenna is used.

• • •

Audio Design for Battery-Powered Receivers

TO DESIGN RECEIVERS capable of high efficiency over a long operating range of battery voltage, Sylvania Electric Products suggests the use of tubes optimized for low voltage conditions. Such types include the 1LB4, 1LD5, 1LC6, and 1LC5. Portable receivers present the alternatives, for battery economy, of using a maximum supply of 45 v or using a 90 or 67½-v battery allowed to fall below the usual end-of-life voltage.

Considering the design of an audio section using a 1LD5 resistance-coupled to drive a 1LB4, since the optimum values of load and bias resistors differ for the three operating conditions, and since it is not practical to change these values in service, compromise values must be selected to give satisfactory operation over the desired voltage range. Figure 1 shows the effect on power

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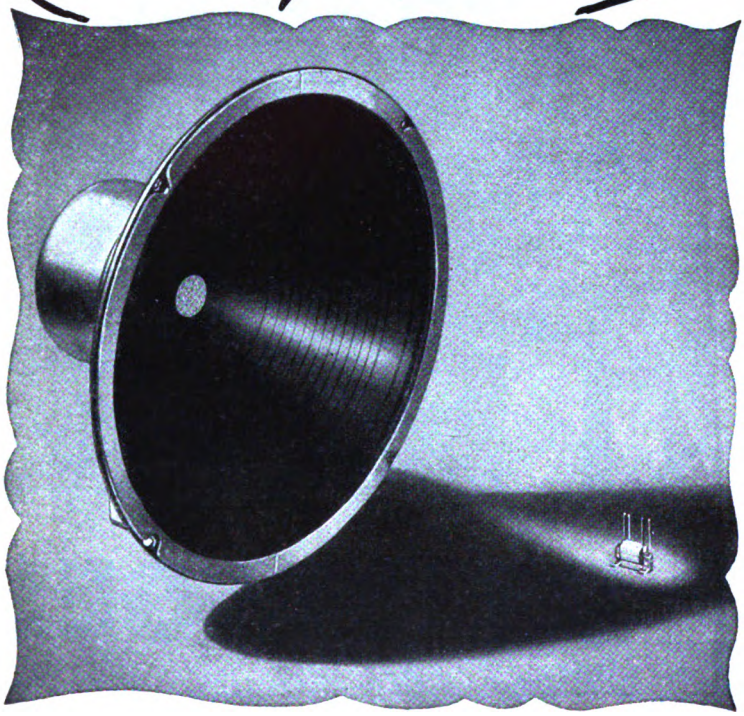

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output of changes in load and bias resistances. The data shown are with the maximum signal which gives 10 percent total distortion.

Values selected for best average performance, considering the plate current drain, are 1500 ohms for

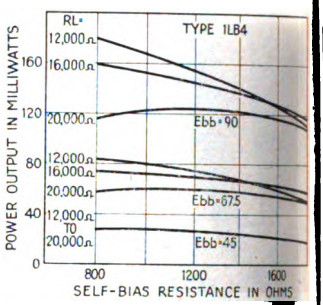

Fig. 1—Plot of effect on power output of changes in load and bias resistance for type 1LB4 tube

biasing, and 12,000 to 16,000 ohms load. As shown by the curves, the value of load resistance becomes less important at the lower voltage but the lower values of bias resistance cause a disproportionate increase in current drain for a small additional power output. Values of output power shown include that lost in the output transformer, as the test circuit used a choke having 100 ohms resistance which approached ideal conditions.

Filament voltage was maintained

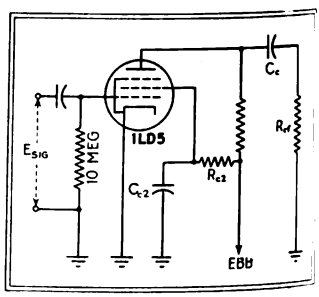

Fig. 2—Circuit used with formulas in text to calculate by-pass capacitor values by rapid method

at 1.4 volts so another variable would not be introduced.

Audio Bypass Values

The circuit in Fig. 2 relates to a short-cut method of calculating

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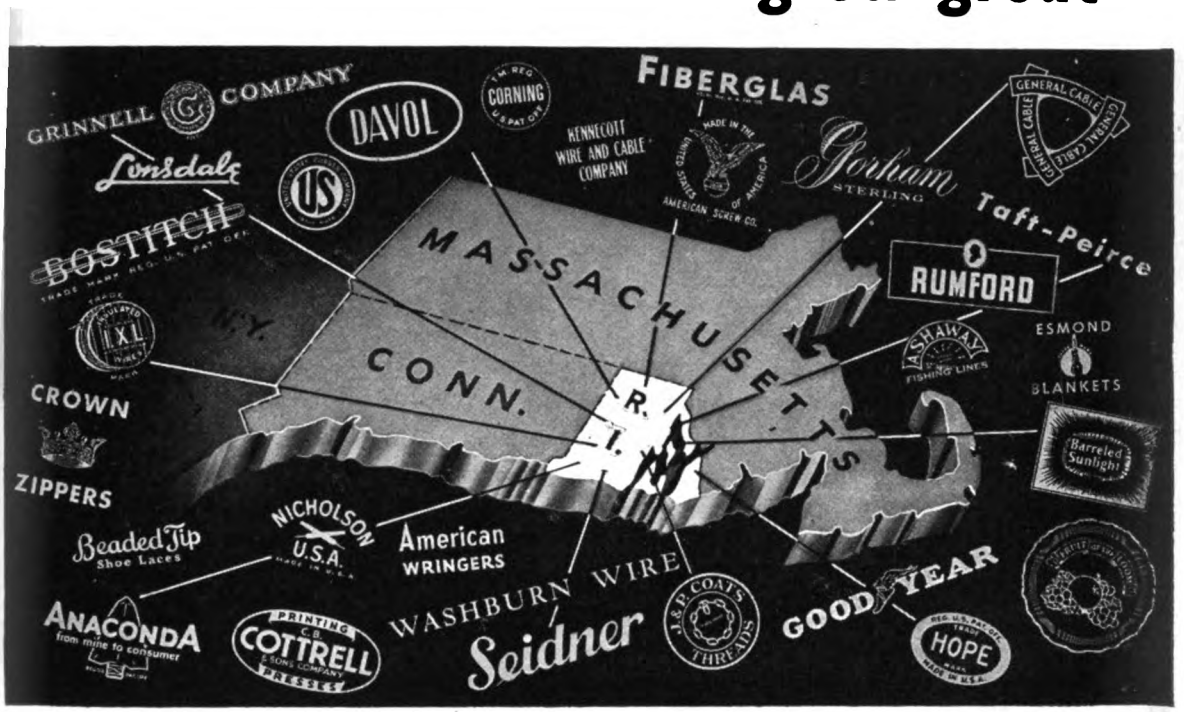

FOR over 150 years, Southern New England's *first manufactures*—firearms, clocks, copper and brass—have been growing more and more famous.

Products of other industries which followed have won wide acceptance, too . . . such as Rhode Island's paint, rubber goods, wire, cable, tools, textiles, glassware, piping, packaged foods, silverware, machines.

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A place for your family, too . . . because Southern New England is a region just as inviting for good living as it is for manufacturing.

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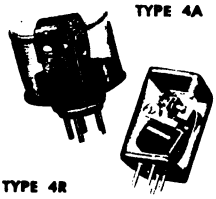
TYPE 4F

This is the Series 4 relay with open frame construction. It is compact (1⅝" x 1⅜" x 1⅝₂"), fast (2 - - 3 milliseconds with sufficient power), sensitive (.010 watts minimum).

TYPE 4A

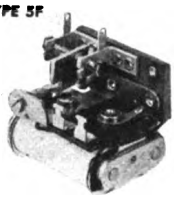


TYPE 4R

TYPES 4A AND 4R

These are the basic Series 4 construction with enclosures. The 4A is 2⅛" diameter and 2⅛" high, the 4R ½" x 1½" x 2⅝". Both have a 5-pin plug in base. The 4A can be sealed (4AH).

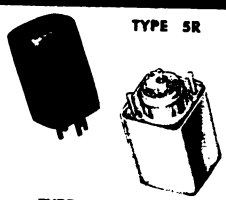
TYPE 5F



TYPE 5F

This is the Series 5 relay with open frame construction. It is exceedingly sensitive (.0005 watts minimum), very rugged, precise in operation even under extremes of temperature and vibration.

TYPE 5R



TYPE 4 (or 5) RJLB2

TYPES 5R AND 4 (or 5) RJLB2

5R is the Series 5 construction in an enclosure (1½" x 1½" x 2¼") with a 5-pin plug in base. The RJLB2 is a hermetically sealed enclosure with two mounting bolts available for both the Series 4 and 5 relays.

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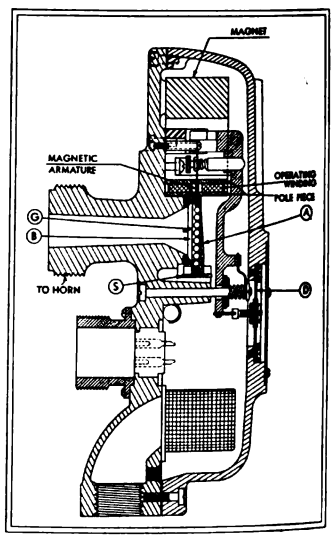
the values of bypass capacitors C_{c1} and C_{c}. Depending mainly upon the frequency characteristics required and where the low-frequency limit is f_1, $C_{c2} = (1.6 \times 10_6)/(f_1 R_{c1})$ μf and $C_c = (1.6 \times 10^6)/(f_1 R_{c1})$ μf. This method is quite rapid and gives conservative values with a loss from incomplete bypassing less than one percent. Capacitor size can be halved where economy is essential unless stages are cascaded and highest quality is required.

• • •

Modulated-Air Super Speaker

APPLYING THE PRINCIPLES by which the human larynx uses vibrating vocal cords to modulate air flow from the lungs, a super-power loudspeaker substitutes an air compressor and a modulating air valve.

As shown in an accompanying illustration the unit was given tests which showed a coverage up to four miles under favorable conditions. Messages spoken in a whisper were audible as far as a mile through high noise levels. It has been heard as far as 18 mi.



Fluid-flow unit in cross-section. Identification of parts is in the text. Modulation of compressor-supplied air is accomplished at interface G

This particular model operates at 20 to 25 psi of air and dissipates 15 to 20 w of audio power. Higher pressures produce greater outputs

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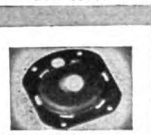
KAYGREY magneto insulator

KAYGREY formed insert

DURO motor slot cell

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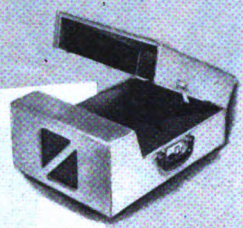

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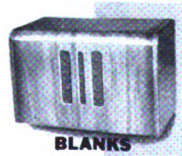

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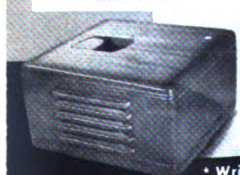

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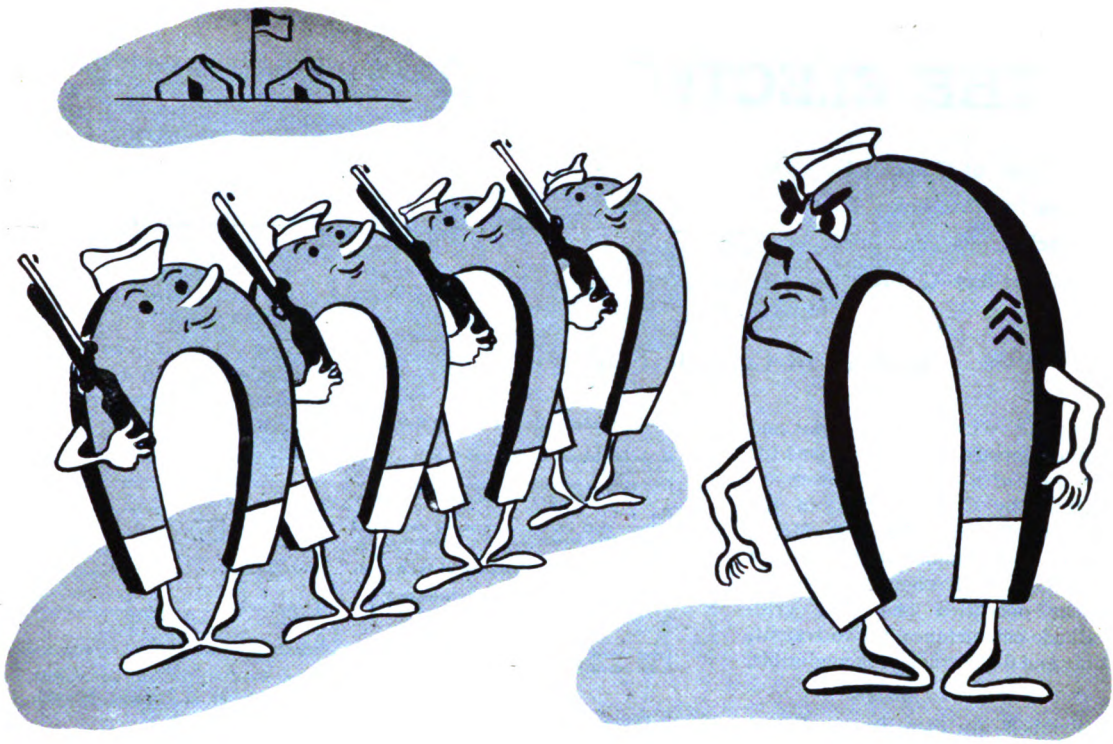

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THE ELECTRON ART

Analysis of Cathode Follower 434
Sensitive Gas Relay Tube 450
Synchronous Time Base 458
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Analysis of Cathode Follower

EQUIVALENT CIRCUITS for input and output impedance and equations for the gain of a cathode follower are derived by C. N. Jeffery in the *A.W.A. Technical Review*, March 1945. It is assumed that the input signal is small enough to ensure linear operation and that grid-cathode conductance due to transit-time and dielectric loss is negligible.

Input Impedance

Symbols are identified in Fig. 1 and Table I. From conventional circuit analysis the input impedance is found to be

$$Z_{in}' = [r_p Z_1/(r_p + Z_1)] + Z_{gk} + \frac{}{g_m Z_{gk}[r_p Z_1/(r_p + Z_1)]} \quad (1)$$

The equivalent circuit for input impedance is that of Fig. 2.

At low frequencies where inter-electrode and distributed reactances are considerably greater than resistances in parallel with them the equivalent circuit is that of Fig. 3A. The conditions represented in

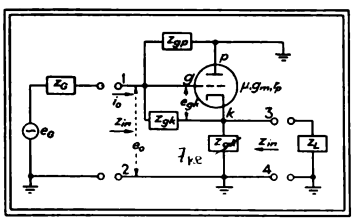


Fig. 1—Terms and symbols used in text. Inter-electrode capacitances are understood to be a part of the various impedances

this circuit are that the grid-cathode bias is obtained through R_{gk} to a tap on R_{k_2}, this tapped portion being small enough compared to R_{k_2} to be neglected; and that x is the ratio of the effective output load to the normal output impedance, $1/g_m$ (a fact to be deduced later). This circuit indicates that

Table I—Cathode Follower Circuit Symbols

Z_{gp}	Grid-plate impedance (assumed to be $-j/\omega C_{gp}$)
Z_{gk}	Grid-cathode impedance, a capacitance $-j/\omega C_{gk}$ which may be shunted by resistance R_{gk}
Z_{k_2}	Cathode-earth impedance, normally resistor R_{k_2} considerably greater than $1/g_m$, shunted as discussed
Z_G	Internal impedance of generator of emf e_G connected to terminals 1, 2
Z_L	Impedance of load connected to terminals 3, 4
Z_1	Z_L, Z_{k_2} in parallel
Z_2	Z_G, Z_{gp} in parallel
Z_3	Z_L, Z_{k_2}, r_p in parallel
Z_{in}'	Input impedance without Z_{gp} in parallel
Z_{in}	Input impedance with Z_{gp} in parallel

input resistance is increased, particularly if x is large. In practice the load is generally a resistance of the order $1/g_m$, thus the input resistance is $2R_{gk} + 1/g_m$.

At high frequencies where inter-electrode reactances are much less than their associated resistances, if the load is capacitive the equivalent circuit is that of Fig. 3B. The negative resistance term may produce oscillation if the generator and input impedances combine to form a resonant circuit. The negative resistance can be neutralized by a series resistance whose value is

$$R_s = \frac{(1/g_m)\,(C_3 C_{gk}/C_{gp}^2)}{1 + (\omega^2/g_m^2)\,(C_3 + C_{gk} + C_3 C_{gk}/C_{gp})^2} \quad (2)$$

Because there will be some damping by the tuned circuit, the required grid stopper resistance is less than this value. From Eq. 2 it can be seen that R_s decreases

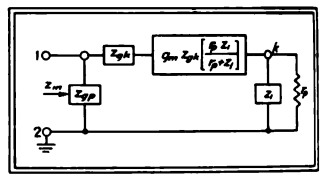
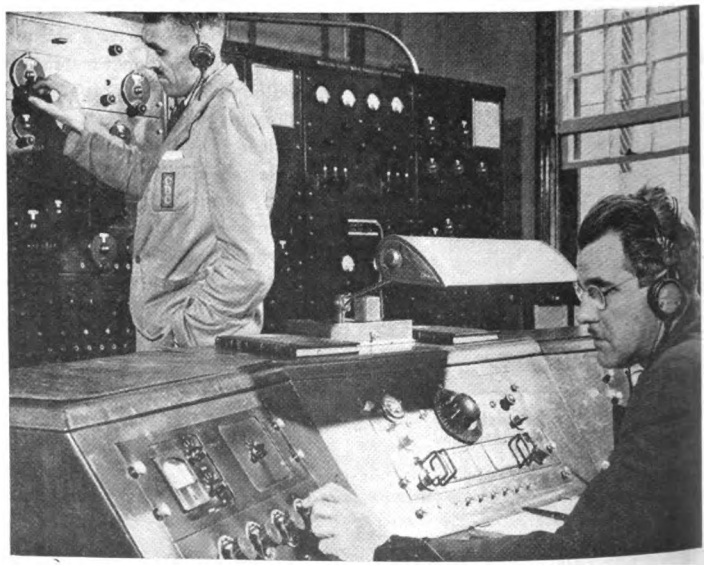


Fig. 2—Generalized equivalent input circuit of cathode follower

with increasing frequency therefore parasitic oscillations at high frequencies require only a small grid stopper.

Some control may be exercised over C_3 which should be kept low. An example arose in practice: Out-

CANADIAN MONITORS



Master control desk at CBC listening post near Ottawa. A Marconi diversity short-wave receiver in the background covers the frequencies from 5 to 25 Mc. Two operators patrol the air lanes 16 hours a day

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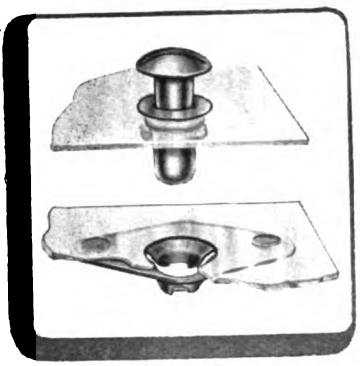
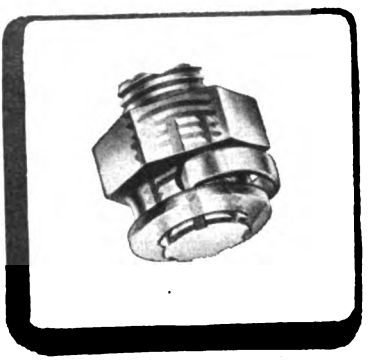


QUICK-LOCK

SIMPLIFIES ACCESS PANEL ASSEMBLIES. A 90° turn locks and unlocks it in a jiffy. QUICK-LOCK requires no special tools. Flexible mounting and tapered stud makes it ideal for assembling curved sheets and insures tight fit when locked. Stud is self-ejecting when unlocked. Minimum deflection is assured—only initial loads are carried by helical spring. Solid supports take increased loads. Let QUICK-LOCK solve your problems.

SPRING-LOCK

ONE-PIECE BLIND FASTENER. Inexpensive one-piece assembly speeds-up blind installation...requires no nuts, receptacles, lock washers or threading. SPRING-LOCK is self adjusting for various material thicknesses. Locks and unlocks with a quarter turn...can be permanently installed as blind rivet...cannot work loose from vibration. Locks with high initial load without deflection.



LOCK NUT

DOUBLE DUTY—LOCK NUT and STOP NUT. An all-purpose safety nut that reduces assembly time. One end of safety ring engages nearest serration on bolt thread. 7 Serrations provide 14 locking positions per revolution. Serrations can be cut by simple broaching operation in a fraction of the time required to drill cotter pin hole. Can be used as stop nut without serrated thread for close adjustment.

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put of a cathode follower was connected to a long cable. On disconnecting the cable load oscillation in the cathode follower commenced due to the large capacitance of the unterminated cable.

If the cathode-earth impedance is effectively a resistance R_s of value

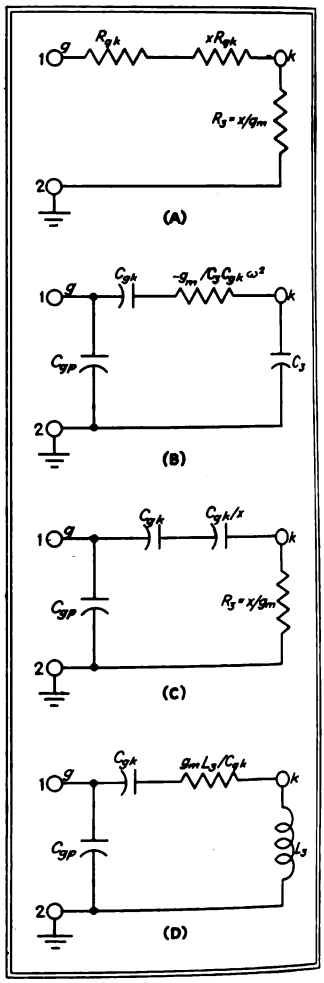

Fig. 3—Cathode follower input circuits for (A) low frequency, (B) capacitive load, (C) resistive load, and (D) inductive load

x/g_m, the equivalent circuit is that of Fig. 3C, which is also the equivalent circuit for low frequencies where grid bias is obtained by returning the grid resistor to a bias battery. If the grid-earth network is reduced to a parallel R-C, the resistance is

$$R_p = R_s + (1 + x)^2/R_sC_{gk}^2\omega^2 \quad (3)$$

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21 DIFFERENT!

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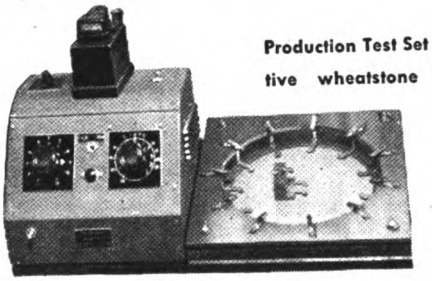

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The damping effect
tuned circuit is less i
a triode than for a p
If the cathode foll
inductive, the equivale
that of Fig. 3D.

Output Imped

From analysis of th
circuit, the general o
of a cathode follower
that of Fig. 4. At low
where in normal pra
$1/g_m$, $\mu > 1$ or $r_p > 1$
vided $R_G > R_{gk}$ the ou
sistance $1/g_m$ and the
duces to that of Fig. 5

In Fig. 5B where th
impedance is a capacit
input capacitance is i
the generator impedan
ductance L_G and the f
such that the equivalen
pedance is also inductiv
and C_{gp} in parallel as i
the shunting term can
zero, negative, or positi
ing on the ratio f/f_s whe
resonant frequency of
circuit L_{in}, C_{gk}. If L_{in} is
oscillations can occur
negative resistance term

If the input is a tuned
dynamic resistance R_d t
lent circuit is that of F
Z_{ke} is capacitive, resonan
cur in the cathode circui
be prevented by making

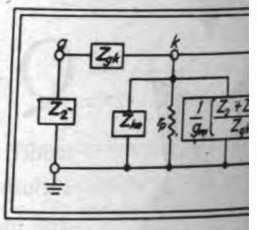

Fig. 4—Generalized equivalen circuit of cathode follow

ode impedance more resistiv
ductive or by damping th
circuit. If it is essential t
output impedance be as ne
possible a resistance $1/g_m$,
at the highest operating fre
is restricted to very low val

Gains

Two types of gain will b

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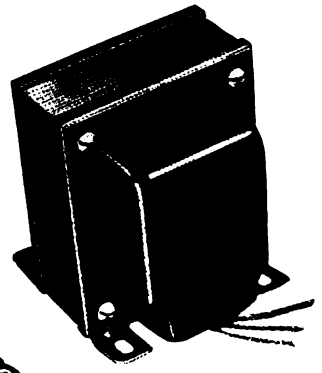

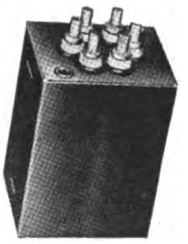

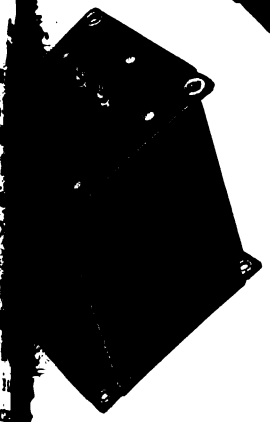

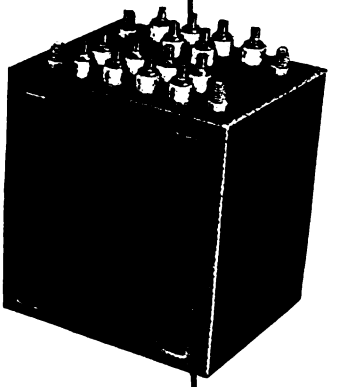

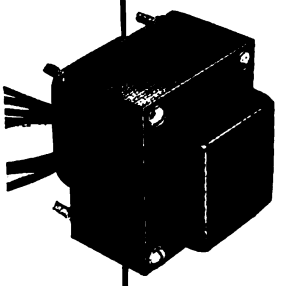

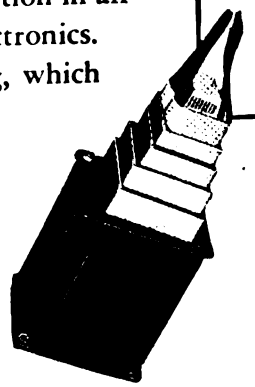

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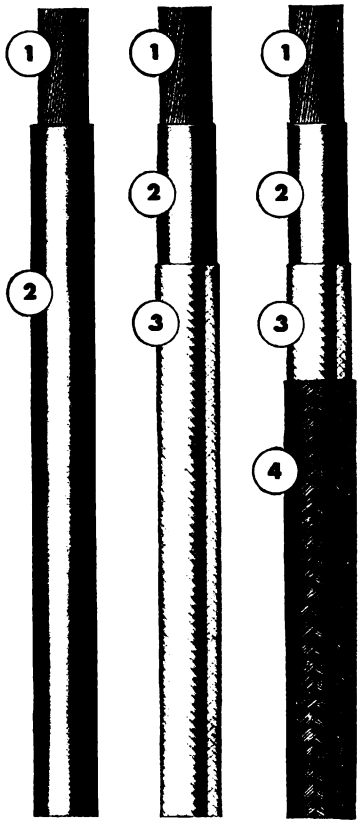

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1. Tinned copper conductor—is flexible, free of lumps, kinks, splits and abrasions.
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GENERAL ELECTRIC

sidered; the stage gain—defined as the ratio of output voltage to grid-earth voltage; and the overall gain—defined as the ration of output to generator input voltages.

The stage gain is

$$\left|\frac{v}{e_g}\right| = \left|\frac{1 + 1/g_m Z_{gk}}{1 + (1/\mu) + (1/g_m Z_{gk}) + 1\,g_m Z_1|}\right| \quad (4)$$

The overall gain is

$$\left|\frac{v}{e_g}\right| = \left|\frac{[Z_{gp}/(Z_{gp} + Z_a)]\,[1 + 1/g_m Z_{gk}]}{1 + \frac{1}{\mu} + \frac{1}{g_m Z_{gk}} + \frac{1}{g_m Z_1} + \frac{Z_{gp}\,(r_p + Z_1) Z_a}{(Z_a + Z_{gp}) r_p Z_1 g_m Z_{gk}}}\right| \quad (5)$$

For low frequency operation Z_{in} is very large thus the stage gain is

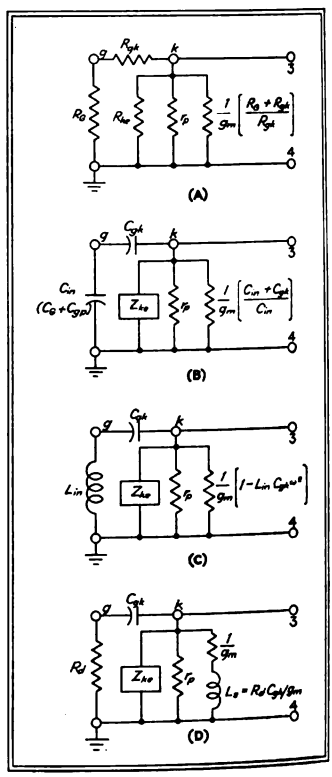

Fig. 5—Cathode follower output circuits for (A) low frequency, (B) capacitive input, (C) inductive input, and (D) resistive input

used. Normally Z_{gk} and Z_1 are considerably greater than $1/g_m$ and if $\mu \gg 1$, the stage gain tends toward unity. If in addition $Z_1 = 1/g_m$, the stage gain is ½.

At high frequencies the input impedance must be considered. Normally the cathode follower is de-

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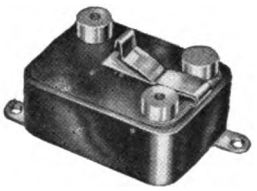

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Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.

Type RT Thermostat. Adjustable Temperature Control.

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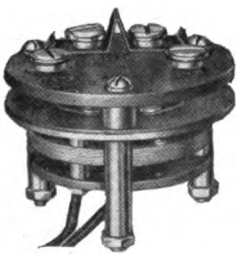
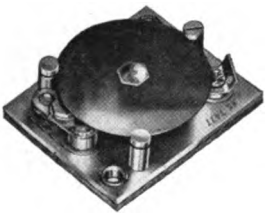
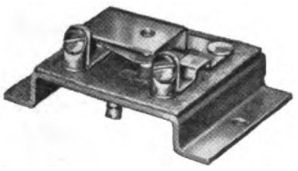


Type ER Series. Ambient Compensated Time Delay Relays.



Type B-3120 Thermostat and Heater, Crystal Dew Point Control.



Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

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signed to feed a resisti
value $1/g_m$, Z_{gk} and Z_{g}
capacitive, and if $\mu \gg 1$,
gain becomes $|(1 + j\omega_{\mu}$
$j\omega C_{gk}/g_m)|$. The overall
similarly be reduced to
expression.

Conclusions

It is difficult to define
merit for comparing va
used in cathode followe
However the following
ments are required at t
frequencies: low output
for connection to concen
or low-impedance netw
high).

Output impedance in
of generator (input)
(C_{gk} low).

Freedom from oscillatio
ode impedance becomes c
as from removing the lo
end of a transmission line
to the cathode follower
high).

High input resistance w
put is correctly terminated
high).

From these requirements
tive figure of merit of g_m/
suggested. Applying this
merit to typical valves
that the triode is approxim
percent better that the pen

Where input capacitance
portant C_{gk} should be con
If this parameter is include
figure of merit, the triode is
cent better than the pento
additional material on cath
lowers the reader is refe
Lockhart, C. E. writing i
tronic Engineering 15, 287;
and 16, 21 (1942-1943).

• • •

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tube for amplification of pul
nals, is described in *Wireless*
(Iliffe & Sons Ltd., London
August 1945 by J. Reiss from
mation given by the inventor
Lalewicz. The tube—suitabl
amplification of weak d-c
such as those derived from p
tubes in high speed telegraph
mitters or from the detector
receiver in such a communic

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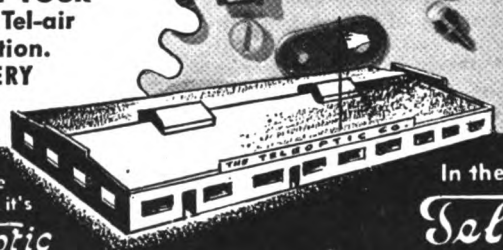

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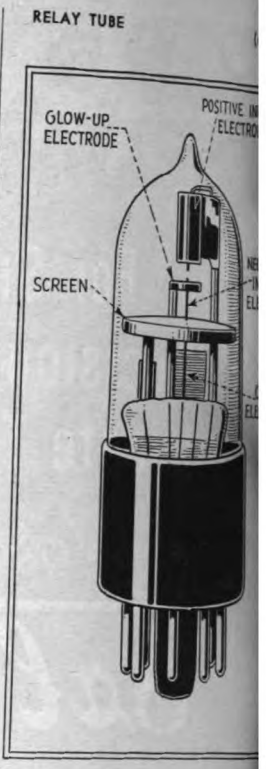

Fig. 1—Addition of a screen d separate input and output elect and a glow-up electrode to maint pilot discharge produces a high-s sensitive relay amplifier tub

circuit, in sensitive relay ci and in decreasing the fly-back of time-base circuits—is illust in Fig. 1.

Operating Characteristics

The screen serves to limi passive glow to the input porti the tube. At a critical input rent the gas discharge ex

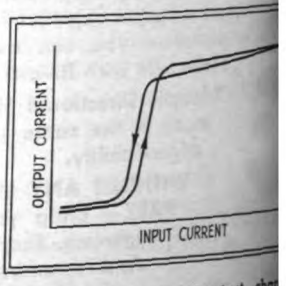

Fig. 2—Relative input-output char teristic of the Teleion indicates how a critical point on the characteristic small decrement in the input produc a large change in the output

through the screen into the reg of the output electrode, if the put is increasing; or withdra from the output electrode regi if the input is decreasing as sho in Fig. 2.

By maintaining a constant g

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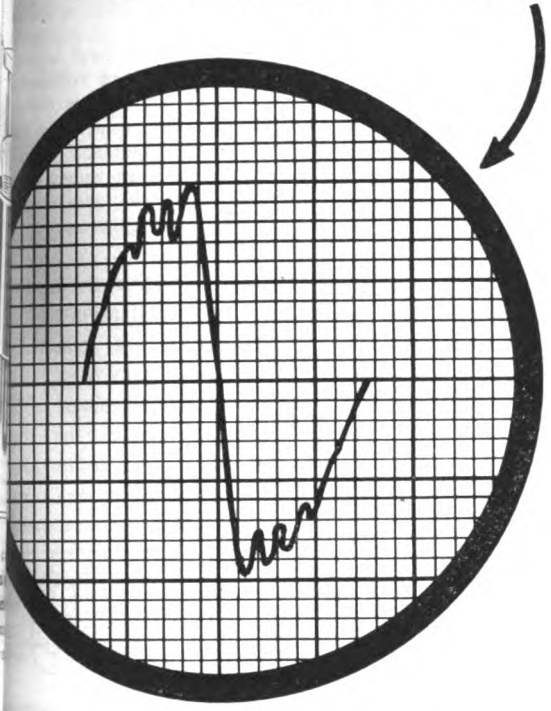

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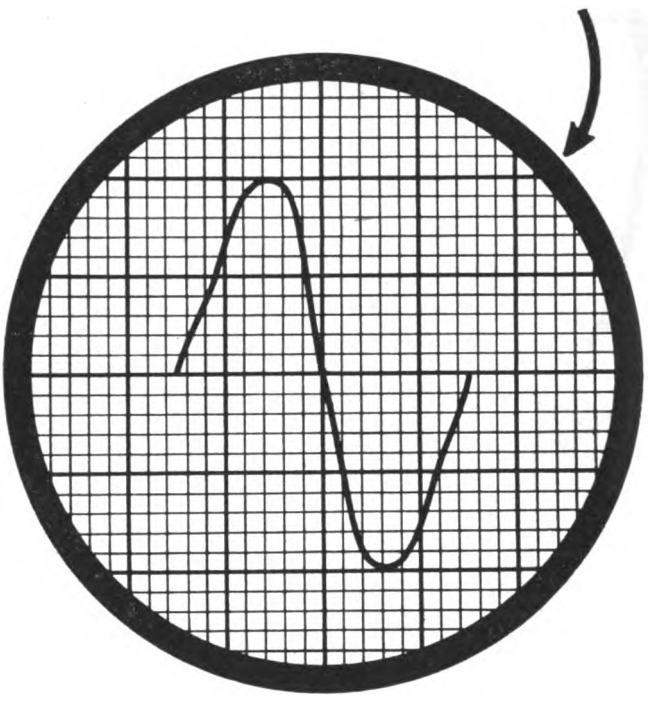

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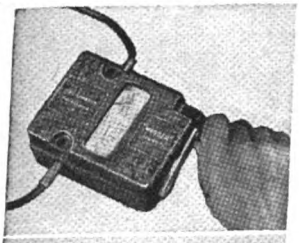

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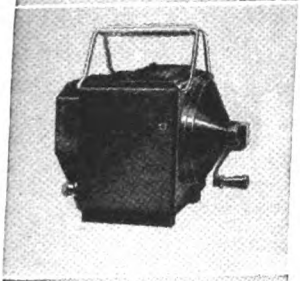

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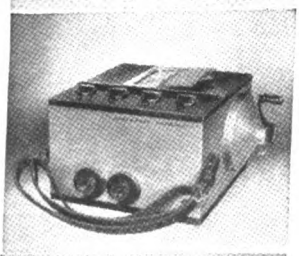

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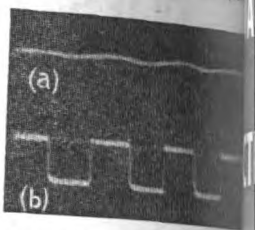

Fig. 3—Trace of input (a) and (b) on a two-beam oscilloscope the pulse amplification obtain 1000 cps. The output peak volt 100 volts. Exponential decay square waves are caused by st actances in the connections oscilloscope

discharge within the tube th tations of ionization and dei tion times are removed. merely necessary to extend or draw the glow volume of the Figure 3 shows the abru with which this action takes

Figure 4 gives the circuit

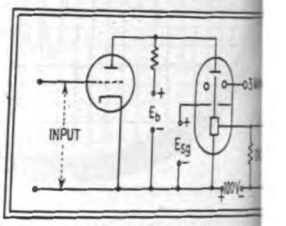

Fig. 4—Typical circuit connection s sensitive gas amplifier tube. Bec the gas tube maintains practically stant potential across its input ci there is no plate potential variatio the driver tube thus no plate coup feedback to the input of the circu

nections of the Teleion. As a dication of its sensitivity, the was used in a simple relay ci in which it provided a 10 watt put for a change in the input cuit of one $\mu\mu f$.

• • •

Synchronous Time Base

A DRIVEN TIME BASE operating dependently of meta-stable circu is described by Hilary Moss in August 1945 *Wireless Engine* The time base is driven, not loc in, by the signal thus giving a tr that has been photographed wi 20 seconds exposure. Definition the traces, especially of the flyba portions, testifies to the obtainab stability.

Basic Circuit

In the circuit shown in Fig.

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resistor R_1 and capacitor C_1 comprise the conventional *R-C* time constant circuit of a saw-tooth oscillator. R_1 can be replaced by a constant current circuit. Charging of C_1 through R_1 provides the forward sweep voltage.

The plate circuit of a low-impedance vacuum tube V_1 is connected across C_1 and biased to cut-off by the voltage drop across R_2. The signal is feed to the grid of

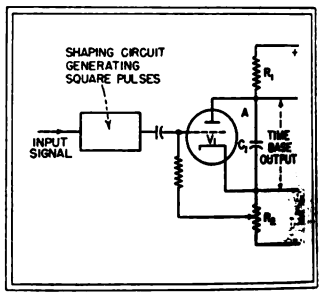

Fig. 1—Grid-controlled vacuum tube driven from signal is used to discharge capacitor in time base generator

V_1 through a shaping circuit (of the saturation cut-off type, not of the triggered multi-vibrator variety, otherwise the freedom from meta-stable circuits would not be retained) that delivers positive pulses of short duration which make tube V_1 conductive (Ed Note: The English say "which opens the valve"; a more direct grammatical statement and a clear physical description showing the superiority of a functional nomenclature, the English, over a pictorial nomenclature, the American, in technical fields.) thereby discharging C_1 to produce the flyback of the time base. A delay network can be incorporated in the shaping circuit so that flyback can be adjusted to any desired portion of the signal under examination.

Gate Stage

The circuit of Fig. 1 provides a single-cycle time base. If a multi-cycle base is required, a gate must be introduced to prevent V_1 from conducting on every positive pulse delivered from the signal by the shaping circuit. Of several possible methods of developing such gate action, that of Fig. 2 is the most

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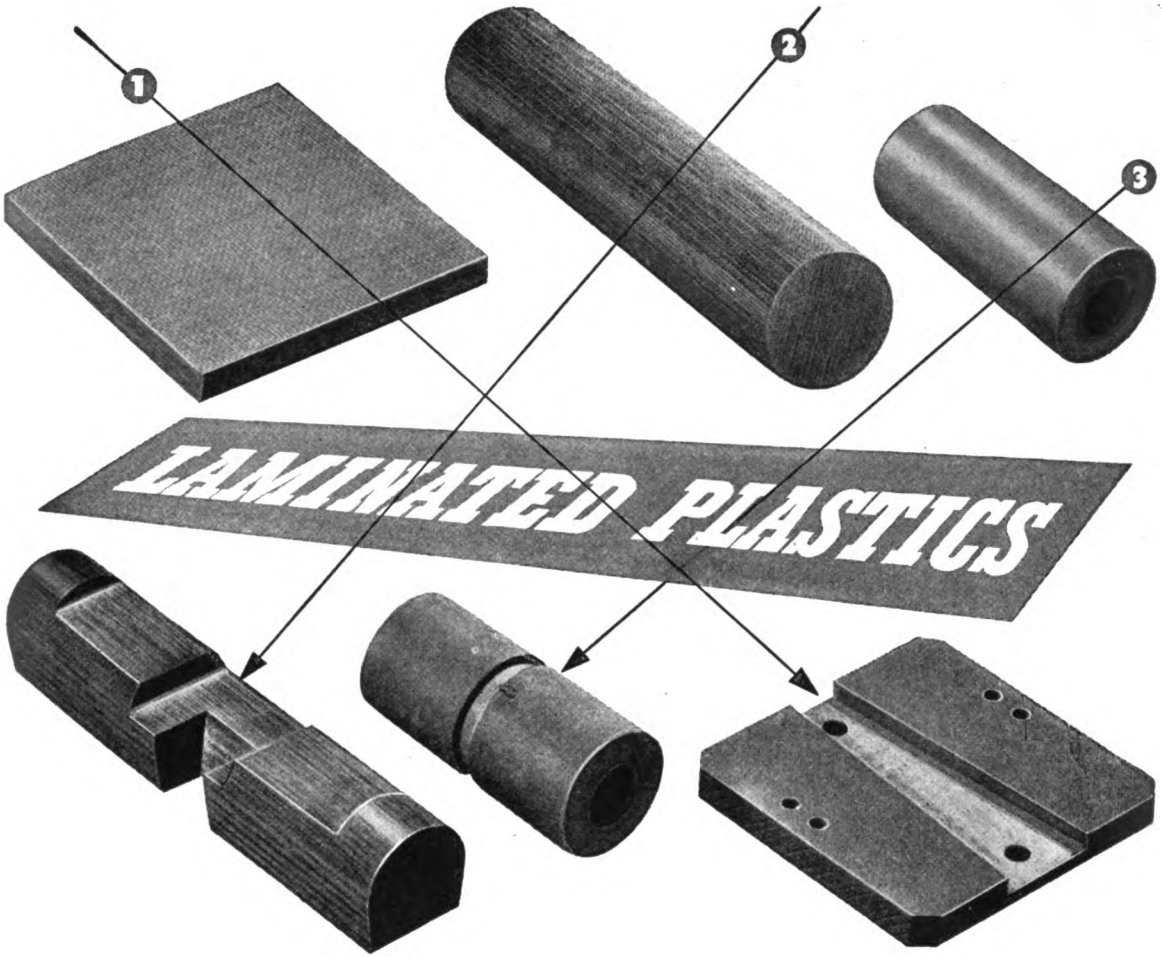

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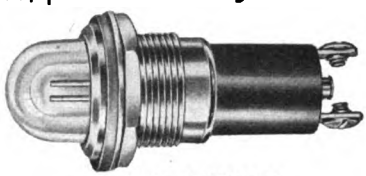

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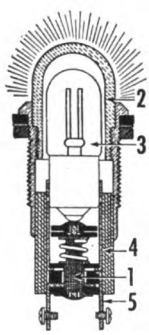

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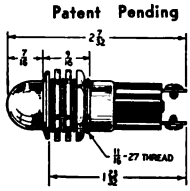

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satisfactory in this application.

The grid of V_2 is biased well below cut-off but as C_1 becomes charged the grid becomes more positive. By choice of R_1C_1 and grid bias the number of cycles of the signal that pass before V_2 becomes conducting can be controlled. Once

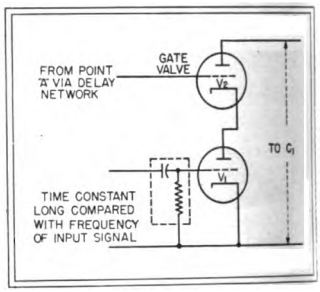

Fig. 2—Gate valve in series with signal-controlled tube provides frequency-dividing action

V_2 becomes conductive, the next positive pulse reaching the grid of V_1 terminates the sweep cycle. The grid of V_2 should have a high slope characteristic so that the tube transfers abruptly from its non-conducting to its conducting state to assure that there is a minimum risk of partial opening of the gate on an earlier signal pulse.

As soon as the V_1-V_2 circuit becomes conducting, C_1 begins to discharge thereby lowering the voltage on the grid of V_2. This action opens the discharge circuit before it has had opportunity to sufficiently discharge the capacitor. A delay network between capacitor and gate tube grid gives time for capacitor discharge before the gate closes. Incorporating the gate in the shaping circuit is apt to produce a pulse on the grid of V_1 when the gate closes, resulting in the saw tooth wave synchronizing with itself rather than with the external signal.

• • •

Cathode-Ray Q Meter

By RUDOLF FELDT
From DuMont Oscillographer March-April 1945

LOGARITHMIC DECREMENT and Q can be measured by the cathode-ray oscilloscope. This method of plotting damped oscillations as fixed images on the cathode-ray tube has

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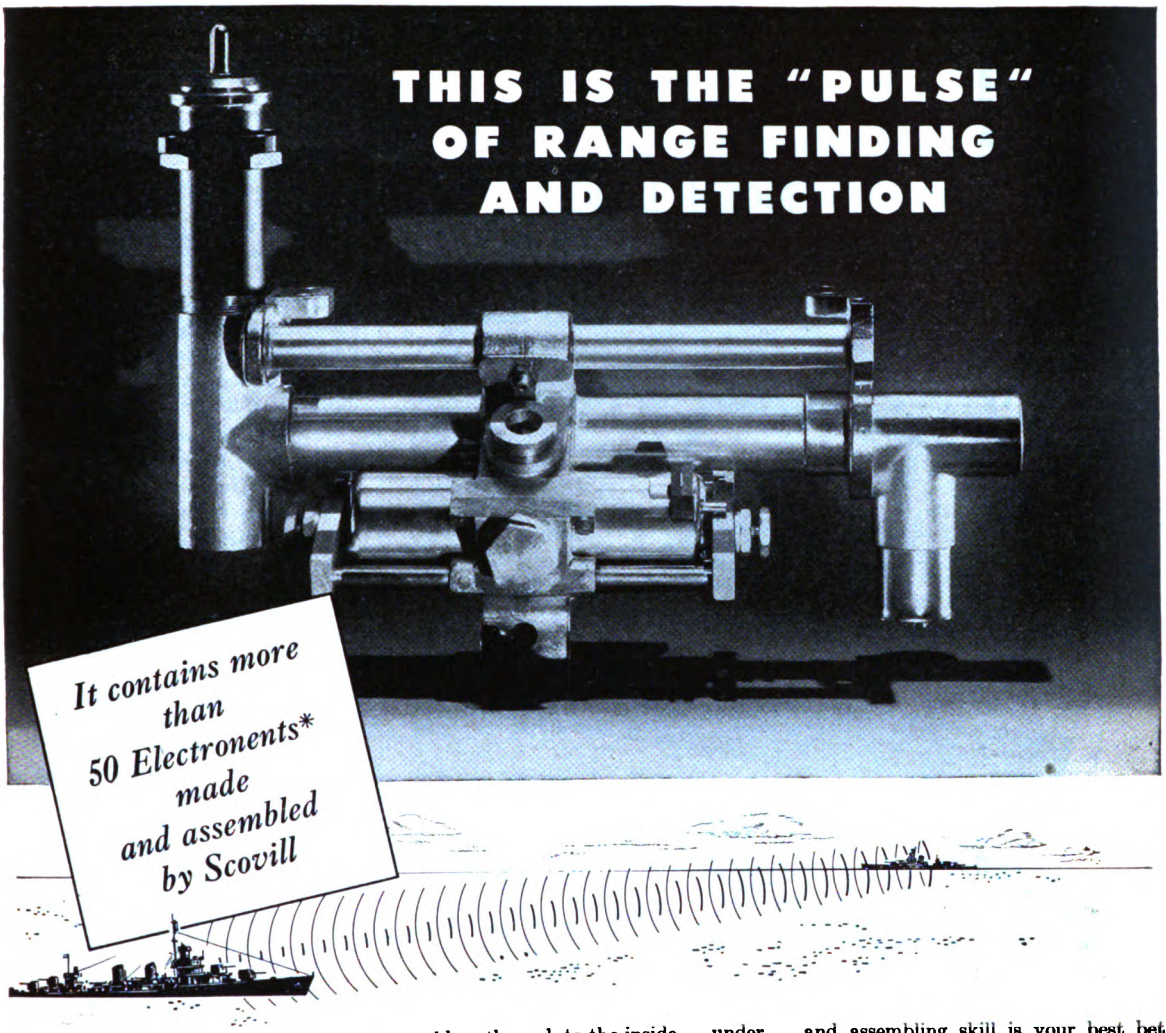

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both electrical and mechanical significance.

Theory

Any system which is able to oscillate will generate damped oscillations if excited by shock. The frequency of these oscillations is determined by the inductance and capacitance of the system, and the damping of the oscillations by losses in the system. A damped oscillation is expressed by

$$A_t = Ae^{-\alpha t} \cos \omega t \quad (1)$$

where A_t is the voltage across the circuit at any time t

A is the voltage at the moment of excitation, time T

ω is the natural angular velocity of the circuit

α is the decrement factio given by $\alpha = R/2L$

R is the equivalent total series resistance of the circuit

L is the equivalent series inductance of the circuit

Logarithmic decrement δ is defined as the natural logarithm of the ratio of maximum voltage dur-

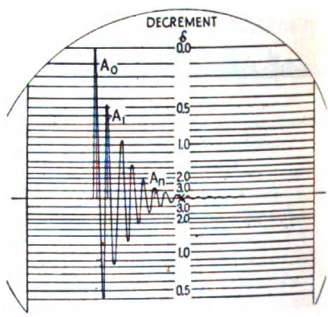

Fig. 1—Decrement is determined from the amplitudes of successive peaks of a free running, oscillating circuit

ing any given cycle of oscillation to the maximum voltage of the next cycle. Logarithmic decrement is equal to decrement factor α divided by natural frequency f. Referring to Fig. 1

$$\delta = \alpha/f = R/2fL = (1/n) \ln (A/A_n) \quad (2)$$

From Eq. 2

$$Q = \pi/\delta = n\pi/\ln (A/A_n) \quad (3)$$

Measurement

Shock excitation of tuned circuits can be obtained either by applying

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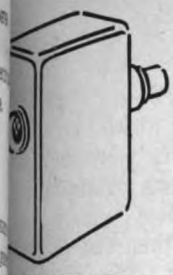
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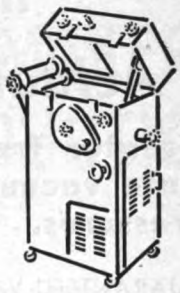
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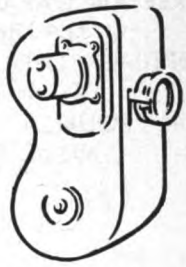
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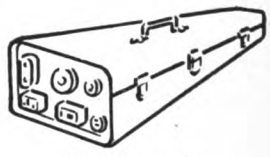
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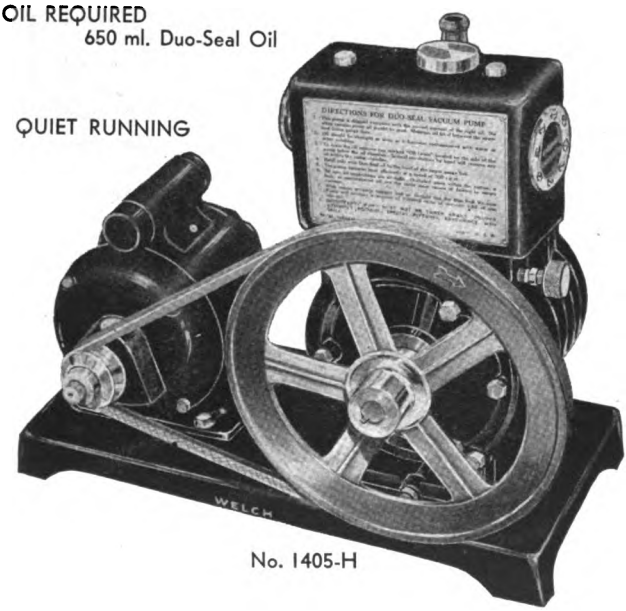

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square waves or by differentiating the saw-tooth wave of the sweep generator, which is a part of almost every cathode-ray oscilloscope, thereby obtaining repetitive pulses. These square waves or pulses are then fed to the oscillatory circuit. The damped oscillations that are generated are applied to the vertical amplifier of the oscilloscope. Sweep is applied to the horizontal amplifier in the usual manner. If pulses from the saw-tooth generator are used, synchronism is necessarily maintained.

Values of decrement and quality can be obtained from the pattern of the damped oscillation or by means of transparent scales placed in front of the cro screen. These scales are drawn from Eq. 2 for δ, and from Eq. 3 for Q. Figure 2 shows such a scale calibrated for logarithmic decrement and Fig. 3 shows a scale for quality.

To measure decrement, the pattern of the damped oscillation is centered on the line marked X on the scale. Amplitude of the oscillations are adjusted (conveniently by the gain of the oscilloscope amplifier) so that one peak touches the zero reference line. The amplitude of the next peak indicates on the scale the value of δ. If the value at the nth successive peak is read, divide by n to obtain δ.

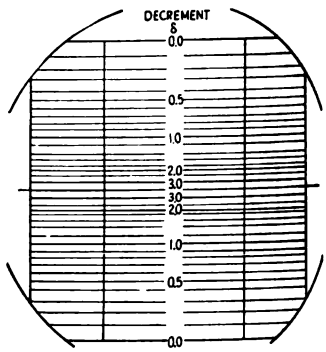

Fig. 2—Scale for measuring decrement directly

Quality can be determined in a similar manner using the scale of Fig. 3. In this case the reference line is marked X. The pattern is adjusted so that one of the amplitudes of the damped oscillation touches the reference line. The next amplitude indicates on the

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ELECTRONIC EQUIPMENT EDITION

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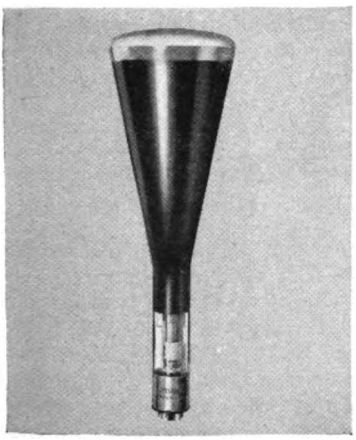
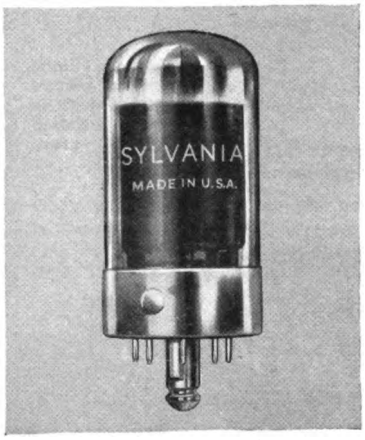


CATHODE RAY TUBES

With the period of reconversion taking active form and spreading over the nation, the radio industry is looking forward to what promises to be one of the most expansive developments in its history. Millions wait for radio sets of improved design and, consequently, of more complex construction. Industries will turn to greater use of electronic equipment.

Manufacturers are rapidly getting set for full-scale production to meet this pent-up demand. Of course, in radio there's the problem of obtaining an adequate supply of component parts.

However, as far as dependable, pre-

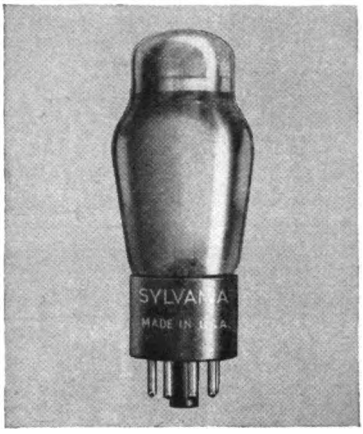


LOCK-IN RADIO TUBES

cision-built radio tubes are concerned, set makers are assured of receiving the benefits of Sylvania's more than 40 years' research experience and wide-scale production facilities. Note this list:

Television—experience in design and the production of untold thousands of Sylvania Cathode Ray Tubes for war requirements has contributed greatly to peace-time applications.

High frequency sets (FM, Television)—the Sylvania Lock-In Tube is so electrically and mechanically perfect in construction that it can handle



"GLASS" RADIO TUBES

ultra-high frequencies with ease. Besides, it is more than perfectly suitable for *all* types of radio sets.

Radio—manufacture and distribution of the famous high quality Sylvania lock-in "Glass" and miniature tubes will continue to satisfy the exacting circuit requirements of modern radio receivers.

Electronic devices—the same laboratory and manufacturing resources that served our government so well, are now available to the manufacturer of electronic devices of every description.

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Emporium, Pa.

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Most resistors are single—but in the Gothard Indicator Light Assembly used with neon lamps, an integral 100,000 ohm resistor is furnished for bright glow and a 200,000 ohm resistor for dimmer glow. Just hook it up. Do you have a Catalog of the complete Gothard Line—write for it!

Model No. 1142 with resistor for neon lamp NE51, also Mazda No.'s 44, 313, and 1815. Lamps available.

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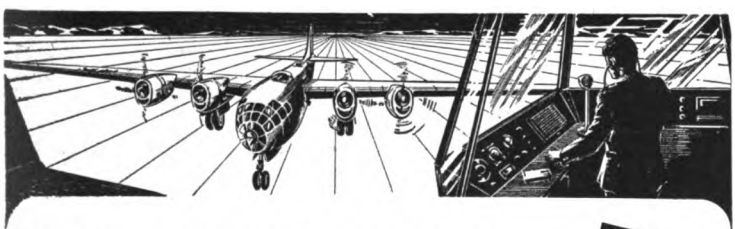

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High current density, low contact drop, low electrical noise, and self-lubrication are characteristics of this silver-impregnated molded graphite that may be the answer to your electrical brush problems

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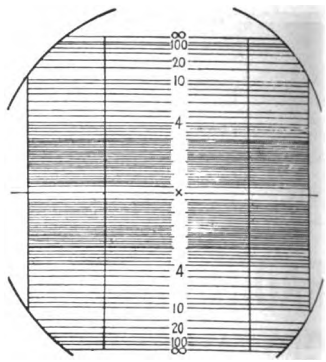

Fig. 3—Scale for measuring quality directly

scale the value of Q or if the scale is read at the nth amplitude it is multiplied by n to obtain Q.

For accurate measurements precautions must be taken to avoid loading of the resonant circuit by the pulse generator and the oscilloscope.

Applications

In Fig. 4 the trace obtained from a vedeo peaking coil having a decrement of about 0.6 is shown. If the voice coil of a loudspeaker is excited by a square wave without introducing electrical damping, the trace indicates damping of the loudspeaker membrane and its resonant frequency.

Any mechanical device which

• • •

300-MC TELEVISION

R. D. Kell and T. L. Gottier made adjustments on an experimental 300-mc transmitter for television developed at the RCA Laboratories

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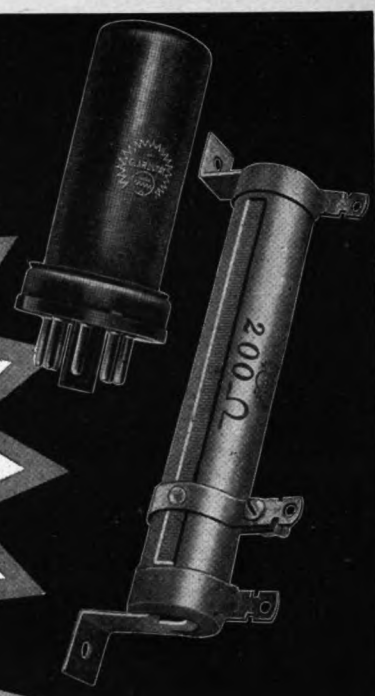

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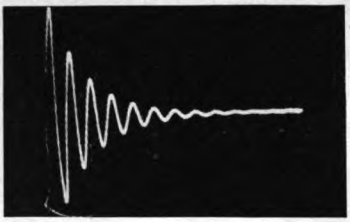

Fig. 4—Typical trace from which decrement and quality can be measured

can be excited by shock to produce vibrations can be measured by this method. If the shock is synchronized with the sweep circuit of the cro and the mechanical vibrations converted into electrical signals by piezoelectric pickups, or electromechanical or photoelectric devices, a steady trace can be produced as in measuring electrical circuits; otherwise an adaption of single trace technique can be made.

• • •

INDUCTION HEATING OF X-RAY TUBE

In the fabrication of the 2,000,000-volt x-ray tube made by Machlett Laboratories, each Kovar and glass ring assembly is sealed by induction heating supplemented by a gas flame. When the section is finished, the column is lowered through the floor so that the work surface is always in position to receive the Kovar-glass seal

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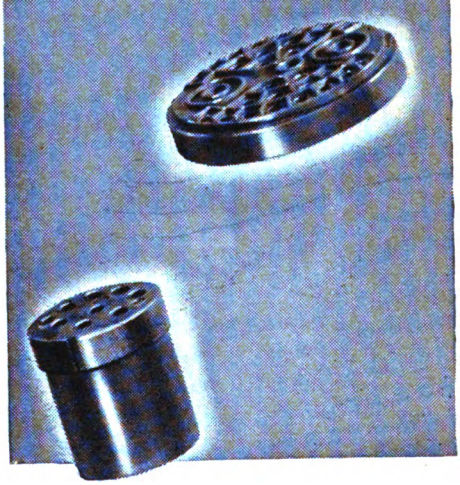
give exceptional service at high altitudes

Plaskon cellulose-filled melamine was developed to meet extraordinary wartime requirements, and now is a proved, available material for your special service needs.

A typical heavy-duty job of this new Plaskon resin is illustrated by the electrical connectors used in many types of aircraft. It performs equally well at extremes of temperature and humidity. The compound has a low power factor, high dielectric strength and arc resistance, and resists tracking after arcing. Good dimensional stability is an important feature.

Other advantages include hardness, permanence, resistance to shock, high chemical resistance and non-inflammability. The compound is not affected by inert organic solvents, and its water absorption is extremely low.

Your production plans may be benefited by Plaskon cellulose-filled melamine. Our experienced field men will be glad to help adapt it to your requirements.



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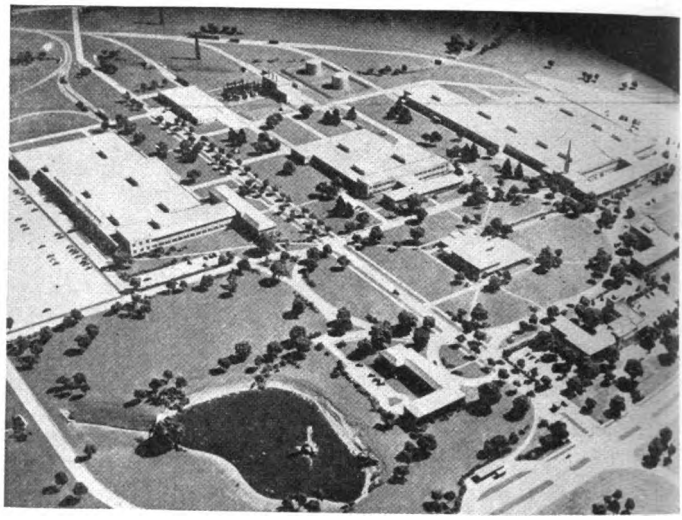
NEWS OF THE INDUSTRY

Assignments and Standards for F-M



Projected Syracuse facilities of GE to be known as Electronics Park are shown here in model-maker's-eye view. Floor area will exceed one million sq ft, total area 150 acres. Plant cost will be $10 million

PREVIOUS F-M LICENSEES and permittees have been given new assignments by FCC. Those broadcasters listed in the table herewith include 49 metropolitan stations and two rural stations.

In making the allocations for metropolitan stations, the Commission has provided for an effective radiated power of 20 kw and an antenna height 500 ft above the average terrain. Where existing antenna heights are in excess of this figure, FCC has required a reduction in effective radiated power so that the service area within the 1000 μv/m contour is substantially similar to what it would be under standard conditions.

Where the existing antenna heights are less than 500 ft, 20 kw has been authorized, but such stations will be required to conform with a minimum 500-ft antenna unless it can be shown to be not feasible.

As set forth in the new regulations which will be described subsequently, the United States is divided into two areas: Area I includes southern New Hampshire; all of Massachusetts, Rhode Island and Connecticut; southeastern New York as far north as Albany—Troy—Schenectady; all of New Jersey, Delaware, and the District of Columbia; Maryland as far west as Hagerstown and eastern Pennsylvania as far west as Harrisburg. Area II comprises the remainder of the United States.

In Area II there are sufficient frequencies so that all existing licensees in any city could be given facilities providing substantially the same coverage and this has been done. In Area I, however, a different situation exists. Thus metropolitan frequencies in any city in Area I will be substantially

Metropolitan Stations

City	Call Letters	Channel Number	Radiated Power, Kw	Antenna Height, Feet	Frequency, Mc
Baton Rouge, La.	WBRL	41	20	500	96.1
Binghamton	WNBF-FM	44	10.5	657	96.7
Boston	WBZ-FM	39	20	455	95.7
Chicago	WBBM-FM	57	10	668	99.3
Chicago	WDLM	59	20	479	99.7
Chicago	WEHS	61	12	616	100.1
Chicago	WGNB	55	20	472	98.9
Chicago	WWZR	55	12	611	98.5
Columbus	WELD	33	20	341	94.5
Detroit	WENA	45	10.5	663	96.9
Detroit	WLOU	43	20	362	96.5
Evansville	WMLL	34	20	281	94.7
Fort Wayne	WOWO-FM	40	20	300	95.9
Hartford	WDRC-FM	32	7.0	758	94.3
Hartford	WTIC-FM	28	9.5	673	93.5
Indianapolis	WABW	35	20	290	94.9
Kansas City	KOZY	60	20	500	99.9
Kansas City	KMBC-FM	50	20	500	97.9
Milwaukee	WMFM	22	20	310	92.3
Nashville	WSM-FM	61	8.5	720	100.1
Philadelphia	KYW-FM	26	20	382	93.1
Philadelphia	WCAU-FM	38	20	366	95.5
Philadelphia	WFIL-FM	32	20	464	94.3
Philadelphia	WIP-FM	30	18	520	93.9
Philadelphia	WIBG-FM	36	20	358	95.1
Pittsburgh	WPEN-FM	40	20	455	95.9
Pittsburgh	KDKA-FM	31	6.5	783	94.1
Rochester	WTNT	33	20	500	94.5
Rochester	WHEF	53	20	387	98.5
Salt Lake City	WHFM	55	20	261	98.9
Schenectady	KSL-FM	61	8.5	720	100.1
Schenectady	WGFM	37	6	805	95.3
South Bend	WBCA	39	6	805	95.7
Springfield, Mass.	WSBF	67	20	312	101.3
Superior, Wisc.	WBZA-FM	56	20	500	99.1
Worcester, Mass.	WDUL	22	20	500	92.3
Worcester, Mass.	WTAG-FM	71	20	477	102.1
Alpine, N. J.	WGTR	69	9.5	680	101.7
New York, N. Y.	WFMN	65	6.0	795	100.9
New York, N. Y.	WQXQ	63	11.5	632	100.5
New York, N. Y.	WABF	53	15	567	98.5
New York, N. Y.	WGYN	61	4	905	100.1
New York, N. Y.	WFCG	59	7.2	747	99.7
New York, N. Y.	WHNF	57	20	455	99.3
New York, N. Y.	WNYC-FM	51	15	560	98.1
New York, N. Y.	WBAM	45	15	559	96.9
New York, N. Y.	WABC-FM	47	5	850	97.3
New York, N. Y.	WEAF-FM	49	1.6	1258	97.7
Jersey City, N. J.	WAAW	41	13.5	590	96.1

Rural Stations

Mt. Washington, N. H.	WMTW	50	10	...	97.9
Winston-Salem, N. C.	WMIT	47	200	...	97.3

Operation of the following is permitted at present sites until the entire Los Angeles area is considered

Los Angeles, Calif.	KHJ-FM	59	4.8	870	99.7
Los Angeles, Calif.	KTLO	61	4.8	870	100.1

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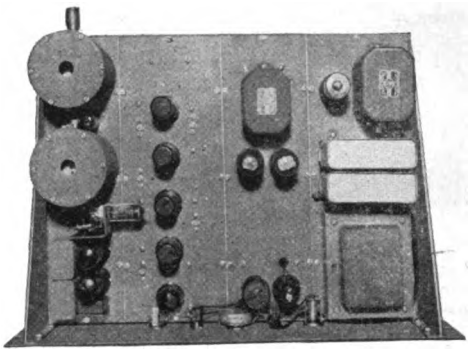
Are You Interested in FCC Allocations Above 100 MC's?



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IF SO—this is the Receiver for YOU!

» The *new* LAVOIE Fixed Frequency Receiver with crystal-controlled oscillator circuit embodying NEW, high-efficiency harmonic generator.

» Frequencies between 100 and 3000 megacycle.

» Details, quotation promptly. Please state your requirements.

Lavoie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists in The Development of UHF Equipment and in The Manufacture of UHF Antennas

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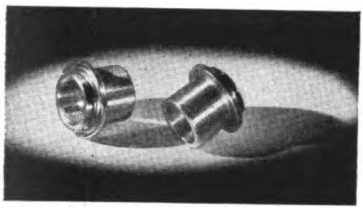
PRECISION PARTS

"SEE" FOR SEA DOGS



". . . from print to product"

A lens-mount is a very necessary part of sound-detection equipment. And, like the hundreds of other equally necessary parts which make up the complete unit, it must be turned out with truly engineered precision to assure perfect operation . . . hairline efficiency.

Ace turned-out this particular part from print to finished product. From stainless-steel bar-stock, Ace machined the blank, tapped a fine-class thread, and thread-ground the O.D. on both sides of the flange, concentric to the inside tapping. Delicate precision . . . accuracy throughout. The entire part was checked on go and no-go gauges again and again throughout each operation to insure concentricity.

Ace is a pioneer in this ever-increasing accuracy which industrial demands have taught to mass-production. Here, under one roof, is a source of supply for small parts or assemblies which call for stamping, machining, heat-treating, or grinding. And Ace offers the modern ingenuity and carefully controlled production you need in current peacetime conversion. Send sketch, sample, or blueprint for quotation.

Capacity open in threads

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equal only so far as the 1000 μv/m contour is concerned. Some channels have the potentiality for coverage of a greater area beyond this protected contour. This factor has applied in the case of New York City, the only point where it was not possible to assign frequencies of substantially the same coverage to all existing stations.

In New York City, therefore, FCC decided to assign frequencies with the maximum service area beyond the 1000 μv/m contour to existing stations that are pioneers in f-m broadcasting. Channels involving smaller service areas have been assigned to the network stations on a substantially equivalent basis with the theory that maximum service will be given to listeners in the area by allowing the non-network pioneer f-m station the greater areas. Network programs will presumably be available beyond the 1000 μv/m contour from network affiliates located closer at hand. It is pointed out as obvious that since the networks all own stations in New York, the independent stations cannot secure network affiliations.

Frequencies assigned to the municipal station WNYC-FM will provide a smaller service area beyond the 1000 μv/m contour than in the case of the other assignments, but this station has previously indicated that its purpose can be served with an area limited to that of New York City.

F-M Rules and Regulations

F-M broadcasters will be governed by rules and regulations promulgated as Subpart B of Part 3 of FCC's general rules and regulations. The arrangement is such as to gather in one place all material relating to f-m broadcasting. It is expected that eventually television, standard broadcast, citizens radio, and other radio services will be revised so that their rules and regulations will fall into similar consolidation.

For convenience, the frequencies available for f-m broadcasting including those assigned to non-commercial educational broadcasting are consecutively numbered beginning with 88.1 mc. Frequency of any channel, therefore, can be ascertained by 87.9 + 0.2

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Available from 450 RPM down to 1 revolution in 1000 hours.

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With friction for resetting. Brake for instant stop. Shift for automatic reset. Reversible.

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POSTWAR MODEL

INTER OFFICE MEMO

Specify Magnavox Capacitors

ECONOMY in size, economy in cost, and efficiency of operation are features Magnavox Electrolytic Capacitors can promise—and deliver.

★★ *Through the use of a finely divided fabricated aluminum anode and improved processing technique, Magnavox builds capacitors to resist severest operating conditions . . . satisfaction is guaranteed.*

★★ Since Magnavox standardizes containers into only eight sizes, design and assembly problems are greatly simplified, assuring greater speed and efficiency.

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offer you these advantages:

They are COMPACT — SILENT — DEPENDABLE TROUBLE-FREE — RUGGED — and

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Many rectifier applications, heretofore considered impractical, have been devised by B-L Engineers. It is more than likely that they can be of assistance in solving your problems of converting AC current to DC... Write for Bulletin R38-a.

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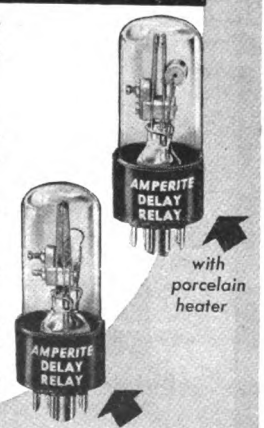
2. Contact ratings up to 115V-10a AC.
3. Hermetically sealed — not affected by altitude, moisture or other climate changes . . . Explosion-proof.
4. Octal radio base for easy replacement.
5. Compact, light, rugged, inexpensive.
6. Circuits available: SPST Normally Open; SPST Normally Closed.

WHAT'S YOUR PROBLEM? Send for "Special Problem Sheet" and Descriptive Bulletin.



with porcelain heater

with heater wound directly on blade

AMPERITE CO. 561 BROADWAY NEW YORK 12, N. Y.
In Canada: Atlas Radio Corp., Ltd.
560 King St. W., Toronto

× channel number. Thus, for example, channel 45 is 96.9 mc.

Three types of stations are outlined in this publication: (1) community stations which are limited to a maximum effective radiated power of 250 w. and a maximum antenna height of 250 ft above the average height of the terrain 10 miles from the transmitter; (2) metropolitan stations which in Area I are limited to a maximum effective radiated power of 20 kw with a non-directional antenna having a height of 500 ft, and in Area II where the Commission will designate service areas and authorize appropriate power and antenna heights to cover them; (3) rural stations which will serve areas predominantly rural in character or where at least 50 percent of the population within the 50 μv/m contour live in rural areas or in communities smaller than 10,000. None are slated to be licensed in Area I as presently defined.

The remainder of the rules cover administrative procedure, licensing policies, equipment considerations, technical and other operations.

Good Engineering Practice

This publication, which is intimately related with the rules previously described, will serve as the official guide for manufacturers involved in the construction of f-m transmitting and receiving equipment. The standards are complete in themselves and supersede the previous engineering standards or policies of the Commission concerning f-m broadcast stations.

Beginning with a short list of definitions, the work proceeds immediately to engineering standards of allocation, topographical data and interference standards, followed by field intensity measurements in allocation, transmitter location, antenna systems, transmitters and associated equipment, indicating instruments, auxiliary transmitters, determination and maintenance of operating power, frequency and modulation monitors at auxiliary transmitters. Also included are requirements for type approval of transmitters, frequency monitors and modulation monitors. Lists of approved transmitters, frequency monitors, and modulation monitors are not included in

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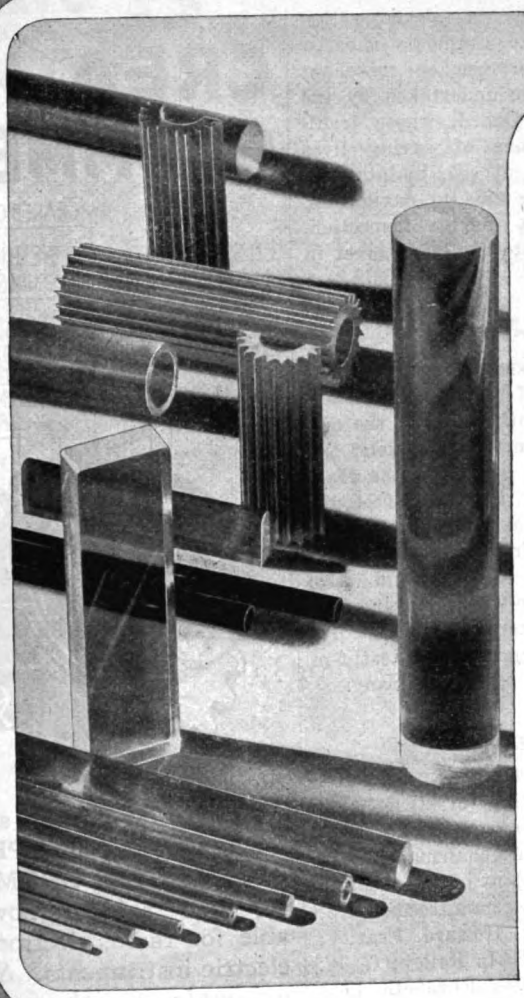
PLAX METHACRYLATE ROD, TUBING AND FIBER



Methacrylate is supplied by Plax in various sizes and shapes of rods and tubing, and in fiber—in all colors, from clear to pearlescent. Characteristics are as follows:

MECHANICAL

Elongation, %	1-5
Tensile Strength, p.s.i.	4,000-7,000
Modulus of Elasticity in Tension, p.s.i.x10^5	3-5
Compressive Strength, p.s.i.	10,000-12,000
Flexural Strength, p.s.i.	10,000-17,000
Rockwell Hardness	M40-M70
Impact Strength, ft. lbs. per in. of notch; ½" x ½" notched bar Izod test	0.2-0.4
Water absorption, 24 hrs., %	0.4-0.5

ELECTRICAL

Volume Resistivity, ohm. cms. (50% rel. hum. at 25°C)		10^{15}
Dielectric Strength, short-time volts per mil, ⅛ in. thick		500
Dielectric Strength, step-by-step volts per mil, ⅛ in. thick		400
Frequency	Dielectric Constant	Power Factor
60	3.0-3.7	0.05-0.07
10^3	3.0-3.5	0.06-0.07
10^6	2.8-3.3	0.02-0.03

THERMAL

Distortion Temperature, °F	125-165
Transition Temperature, °F	145-185
Softening Point, °F	150-230
Specific Heat, cal. per °C per gram	0.35
Burning rate	Slow
Thermal Expansion, 10^{-5} per °C	7-9
Thermal Conductivity, 10^{-4} cal. per sec. per sq. cm/1°C per cm.	5-7
Resistance to Heat (Continuous) °F	120-160

CHEMICAL EFFECTS

Weak Acids	Practically nil
Strong Acids	Affected only by oxidizing acids
Weak Alkalis	Practically nil
Strong Alkalis	Practically nil
Alcohols	Attacked above 40%
Esters	Dissolves
Ketones	Dissolves
Aromatic Hydrocarbons	Dissolves

Liquid sight gauges, transparent models, high frequency insulation, pen and pencil parts, filtration equipment parts, decorative architectural forms, jewelry, etc. may all be advantageously produced from Plax methacrylate rods, tubing and fiber. Methacrylate has unique optical properties . . . For data on stock sizes, write Plax.

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Several bulletins on Plax polystyrene products and how to machine them.

Data on Plax cellulose acetate and cellulose acetate butyrate products.

An article on Plax's blown products.

Ethyl Cellulose, Polyethylene and Styramic are among the other materials offered by Plax in various forms. In cooperation with Shaw Insulator Company, Irvington 11, N. J., Plax can give you help covering nearly all plastic materials and methods. For such help, or for any of the literature listed above . . . write Plax.

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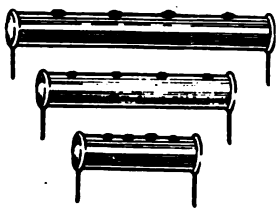
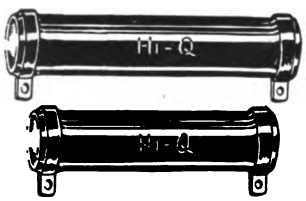
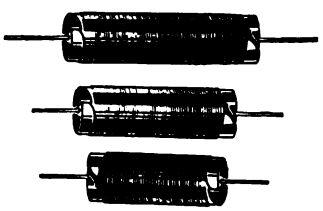


Hi-Q Ceramic Capacitors are of titanium dioxide (for temperature compensating types) and are tested for physical dimensions, temperature co-efficient, power factor and dielectric strength. CI type with axial leads; CN type with parallel leads.



Hi-Q Wire Wound Resistors can be produced promptly and in quantity — with quality physical specifications and high performance electric specifications.



Hi-Q Choke Coils are uniform in their high quality performance. Ruggedly constructed for long service.

ELECTRICAL REACTANCE CORPORATION
FRANKLINVILLE, N. Y.

the publication, but will be issued from time to time by the Commission. The document ends with a list of f-m broadcast application forms.

Maritime Radio and Radar

RESEARCH RELATING to the question of minimum requirements of radar equipment for use on merchant vessels will be undertaken by the U. S. Coast Guard, whose traditional functions of saving lives and property at sea, maintaining and operating aids to navigation, and merchant marine inspection, naturally create a vital interest in this subject.

Canadian F-M

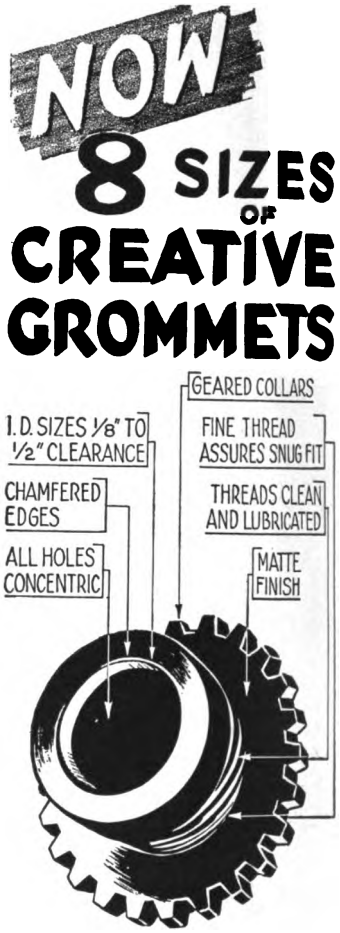
THE FIRST EXPERIMENTAL f-m broadcast station of the Canadian Marconi Co., recently went on the air. Using the Armstrong system, the transmitter is located at the Marconi factory in the town of Mount Royal. It is programmed over high-fidelity lines from studios of Station CFCF in Montreal and operates on 48.8 mc with a power of 25 watts. Call letters are VE9CM. Its immediate purpose is to test f-m receivers built by the company.

IRE Meeting Committee

ACTIVITIES AT THE ANNUAL winter technical meeting of IRE, New York, N. Y., January 23-26, 1946, come under the chairmanship of Edward J. Content of the meeting committee. The committeemen are: Austin Bailey; Howard Frazier; W. B. Lodge; S. L. Bailey; G. W. Bailey, and Miss Elizabeth Lehmann.

First of the major features will be the annual banquet held Thursday, January 24, at which a speaker of national prominence will address the members and their visitors. In addition, there will be entertainment highlights. At this function also, two major annual awards are scheduled to be made: the Institute Medal of Honor awarded in recognition of distinguished service in radio communications, and the Morris Liebmann Memorial Prize made "to a member of the Institute who has made public during the recent past an important contribution to radio communications."

Announcement will then be made



Four new larger sizes of CREATIVE 100% PHENOLIC PLASTIC GROMMETS (up to ½" i.d.) are now available for radio, electronic and electric instruments...*Send for a sample of each of the eight standard stock sizes, mounted on a convenient card.*

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A TELECHRON SWITCH CLOCK MAKES YOUR RADIO AN ALARM

The C-40 Telechron electric radio switch clock gives your low-priced bedside set powerful new sales appeal. The C-40 is an absolutely accurate electric clock — *plus a switch that turns on the radio at any pre-selected time.*

The cost of the C-40 is low. Installation is easy and inexpensive. Operation is simple, too. The alarm is set with a single control knob to the desired time. The clock switches on the radio to awaken the owner with music.

Telechron C-40 is available for panel mounting — with dial and hands styled to your individual needs. The precision-built Telechron synchronous motor guarantees absolutely accurate time. And the exclusive, sealed-in lubrication system assures years of dependable, trouble-free service. For full details, write or wire Industrial Sales Division, Dept. K, Warren Telechron Company, Ashland, Massachusetts.

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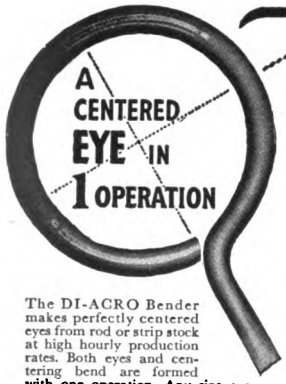

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The DI-ACRO Bender makes perfectly centered eyes from rod or strip stock at high hourly production rates. Both eyes and centering bend are formed with one operation. Any size eye may be formed within capacity of bender and ductile limits of material.

DI-ACRO Precision Bending is accurate to .001" for duplicated parts. DI-ACRO Benders bend angle, channel, rod, tubing, wire, moulding, strip stock, etc. Machines are easily adjustable for simple, compound and reverse bends of varying radii.

DI-ACRO Bender No. 1
Forming radius 2" approx. Capacity ⅜" round cold rolled steel bar or equivalent.

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Forming radius 6" approx. Capacity ½" round cold rolled steel bar, formed cold to 1" radius. Also Bender No. 3, with forming radius 9" approx.

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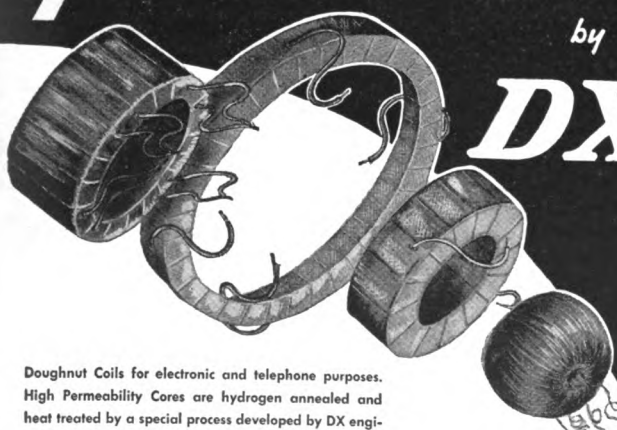

Doughnut Coils for electronic and telephone purposes. High Permeability Cores are hydrogen annealed and heat treated by a special process developed by DX engineers. Send us your "specs" today—ample production facilities for immediate delivery.

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of the appointment of new fellows to the Institute, and the president of the Institute, Dr. William L. Everitt, will address the convention and hand the gavel to the newly elected incoming president.

Next major feature, according to Donald H. Miller, chairman in charge of Special Features, will be the annual President's Luncheon held Friday, January 25, honoring the incoming president.

One of the big events of the Meeting will be the greatly expanded main commercial exhibits. For this purpose all of one floor and part of another in the Astor Hotel have been reserved. It is expected that 150 firms or more will take part in this show, according to H. F. Scarr, chairman in charge of exhibits.

Finally, the major feature of every annual meeting—the reading of scientific papers and the sessions and symposiums on the latest electronic developments—are expected to take on particular significance this year with papers on many vital subjects hitherto restricted by military security.

Tentative subjects scheduled for the meeting, Dr. A. E. Harrison, chairman in charge of Papers, announced, will include: broadcasting, frequency modulation and television; navigational aids; communications and relay links; radar; industrial electronics; testing equipment; new developments in panoramic reception; microwave measuring devices; broadcast receivers; vacuum tubes; antennas and radio wave propagation.

As is customary, all papers will be presented for the first time at this Meeting and none will have been published before in any form. While two technical sessions will be run simultaneously in accordance with last year's successful plan, the papers and sessions will be so arranged that important sessions and expositions on the same subjects or related subjects will not conflict.

Chairmen of technical committees are: P. S. Carter, antennas; L. E. Whittemore, annual review; E. A. Guillemin, circuits; A. C. Keller, electroacoustics; C. J. Young, facsimile; C. C. Chambers, frequency modulation; H. A. Wheeler, handbook; P. D. Zottu, industrial electronics; W. G. Cady, piezoelectric crystals; D. E. Foster,

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radio receivers; J. F. Morrison, radio transmitters; J. A. Stratton, radio wave propagation and utilization; W. T. Cooke, railroad and vehicular communications; R. F. Guy, standards; E. W. Schafer, symbols; I. J. Kaar, television; R. S. Burnap, vacuum tubes.

It is contemplated that the Institute will run organized inspection trips to points of interest throughout the city for out-of-town members.

The Institute of Radio Engineers enters its 33rd Winter session with a membership of more than 16,000 throughout the world, the largest in its history. Of this total, more than 12,000 members are in the United States.

Radio-Television Control of Missiles Announced

PILOTLESS BOMBERS and rockets with television eyes and complete radio control are now a reality, according to Brigadier General David Sarnoff, president of RCA, in speaking at a meeting of the American Academy of Political and Social Science Oct. 5. "So deft, so all-seeing, is the radio-television control", he said, "that from launching sites the operator pressing push-buttons can guide the winged missile as if he were inside its shell. If he sees that the rocket is going to miss the target he can turn it quickly; he can even make it loop-the-loop". Continuing, he envisioned thousands of television-eyed monsters of destruction coming through the skies, loaded with warheads of atomic power, with no nation immune because physical barriers of land and water no longer limit battlefields. "The victor will be the one best fortified by science and development, by discovery and invention, and by the use of scientific weapons in the hands of the ablest fighters."

Television Receiver Parts

TELEVISOR PRODUCTION is expected to divide itself up into a number of different strata, according to Allen B. DuMont of the Allen B. DuMont Laboratories, Passaic, N. J. Hundred-dollar receivers will probably supply the mass audience necessary to sustain the industry. They can be viewed by no more than two or three persons at once. In the next

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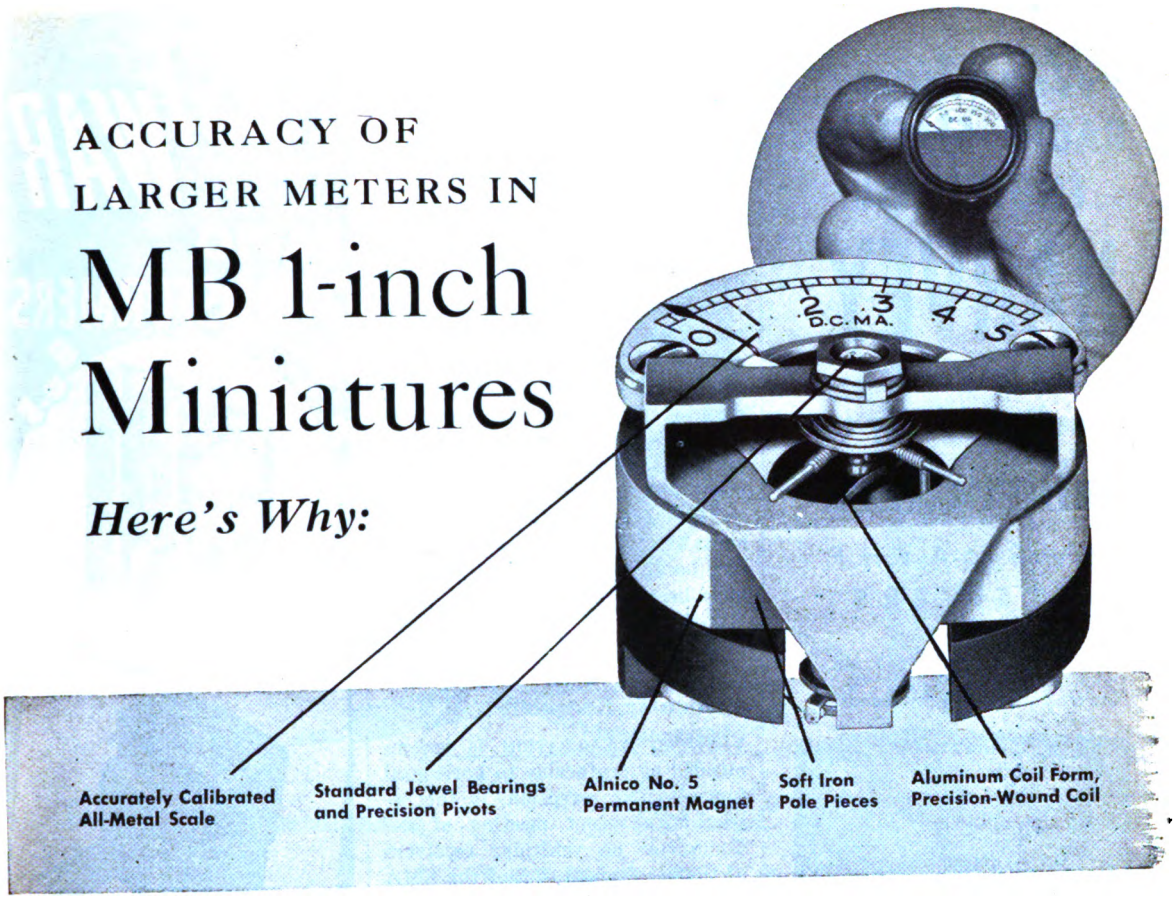

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PLAN TO TAKE ADVANTAGE of this little instrument that does such a big job. It's the smallest, lightest made . . . and you can have the utmost confidence in its performance.

Precision designed and skillfully built, MB meters have the stamina and accuracy to meet the most precise, rigorous tests. Lightweight moving coil mounted on standard size jewel bearings and pivots . . . powerful, retentive magnet . . . hermetically sealed, anodized aluminum case—all combine to give ability to withstand vibration, shock, temperature extremes, moisture.

These 1¼ oz. instruments are available in standard DC ranges from 100 microamperes through 10 milliamperes . . . and 0-10 and 0-50 millivolts. Standard external shunts, multipliers, rectifiers available for other ranges. MB also offers a 1½-inch, 1½ oz. model self-contained in all standard DC ranges, and rectifier-type AC voltmeters, milliammeters.

MB miniature meters are adaptable to a hundred and one uses . . . wherever the measured quantities utilize electrical currents. Any scale or pointer can be specified. Our engineers will be glad to aid in your problems. Write Dept. H for details.

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Instrument Division
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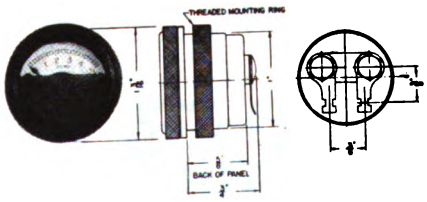

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Model S-36-A V.H.F.

RECEIVERS

FM-AM-CW 27.8 to 143 Mc.

Covers old and new FM Bands

The Model S-36-A is probably the most versatile V.H.F. receiver ever designed. Covering a frequency range of 27.8 to 143 Mc., it performs equally well on AM, FM, or as a communications receiver for CW telegraphy. Equipment of this type was introduced by Hallicrafters more than five years ago and clearly anticipated the present trend toward improved service on the higher frequencies.

Fifteen tubes are employed in the S-36-A including voltage regulator and rectifier. The RF section uses three acorn tubes. The type 956 RF amplifier in conjunction with an intermediate frequency of 5.25 Mc. assures adequate image rejection over the entire range of the receiver. The average over-all sensitivity is better than 5 microvolts and the performance of the S-36-A on the very high frequencies is in every way comparable to that of the best communications receivers on the normal short wave and broadcast bands.

The audio response curve is essentially flat within wide limits and an output of over 3 watts with less than 5% distortion is available. Output terminals for 500 and 5000 ohms and for balanced 600 ohm line are provided.

NOTE: For those requiring higher frequency receivers, Harvey can now supply from stock the Hallicrafters Model S-37, with a frequency range of 130 Mc. to 210 Mc.

Telephone Orders to LO 3-1800

HARVEY RADIO COMPANY

103 WEST 43rd ST., NEW YORK 18, N.Y.

range will come receivers supplying an 8 by 10 or possibly 11 by 14 in. image and running to a price of three hundred dollars or more. Six to twelve people accommodated.

In the upper reaches will be found television on a par with movies, projected on a screen to be viewed by a roomful of people, and the asking price will be around a thousand dollars.

Components constitute the main reason why television prices will be decidedly higher than those for radio receivers. Even with the middle level sets, voltages in the order of 5,000 and over will be involved, and for daily operation good quality parts will be essential to keep servicing at a minimum. Such components are available, DuMont pointed out, because they are the kind that have been used in radar and other war-time electronic devices. However, they are relatively expensive.

Vehicular Receivers

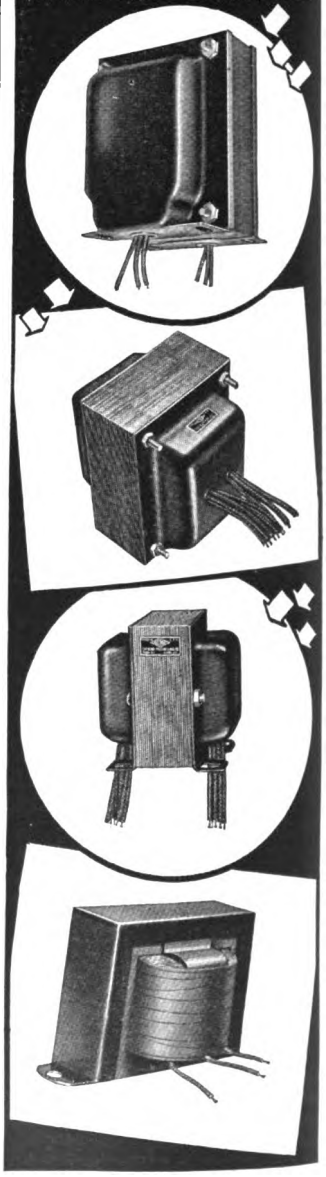
VERTICAL POLARIZATION is recommended as preferable to horizontal for vehicular reception, in the report of a recent meeting of the Committee on vehicular receivers of the receiver section of the RMA Engineering Dept. It was recommended to the executive committee that a statement be adopted to the effect that since vertical polarization gives the most satisfactory reception to automobile radio listeners, broadcasters should consider adding to the cost of their antenna array with the reward of an increased and better served audience.

However, it was not suggested that polarization be frozen without further investigation since it is believed that the manufacturers may be able to produce an antenna which is more efficient for horizontal polarization.

Another resolution which was recommended for incorporation in RMA Standards is related to chassis pickup. Vehicular receivers installed according to manufacturer's instructions and using materials supplied by the manufacturer should exhibit no perceptible chassis pickup with any setting of user controls if they are to qualify under standards of good engineering practice.

"Chassis pickup" was defined as interference arriving at the re-

POST WAR RADIO TRANSFORMERS



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FOR TELEVISION RADAR AND FAC-SIMILE

Wide Band VIDEO AMPLIFIER

Designed primarily for use in amplifying complex waves to be viewed on an oscilloscope, this instrument is also extremely useful in laboratory work as an audio amplifier for tracing and measuring small R. F. Voltages, (as in the early stages of radio receivers,) and many similar applications.

Specifications

BAND WIDTH: Frequency response is flat within. 1.5 DB of the 10 KC response from 15 cycles, to 4 megacycles and 3 DB from 10 cycles to 4.5 megacycles. Phase shift is controlled to provide satisfactory reproduction of pulses on the order of one micro-second, and square waves at repetition rates as low as 180 per second.

GAIN: The gain is approximately 1000 when direct input is used. Use of probe input introduces an attenuation of approximately 10:1.

INPUT is normally through a probe (furnished with the equipment), which has an input circuit consisting of a 1.1 megohm resistance in parallel with approximately 18 mmfd. The amplifier direct input (without probe) is approximately 2.2. megohms of resistance in parallel with 40 mmfd.

OUTPUT voltage can be adjusted from zero to 50 volts R.M.S. with a sine wave signal.

LOAD IMPEDANCE: Designed to work into a load of not more than 22 mmfd.

RIPPLE OUTPUT is less than 0.5 volt for all operating conditions and all positions of gain control.

CIRCUIT FEATURES: A cathode follower input stage provides circuit isolation and is equipped with a 3-position attenuator.

Attenuator ratios are 1:1, 10:1 and 100:1 (This is in addition to probe attenuation). A gain control conveniently varies the video output. A "Signal Polarity" switch is provided which carries the cathode bias on the output stage in such a manner that the amplifier may be adjusted for optimum performance, regardless of the polarity of the input signal.

OPERATING VOLTAGE: 110 to 120 volts, 60 cycles.

POWER CONSUMPTION: 100 watts.

WEIGHT: 35 pounds (Complete with tubes and probe).

WIDTH: 7¾" HEIGHT: 9" LENGTH: 20¾"

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ceiver other than through the antenna, and "perceptible" means that the noise output should be the same with the engine stopped or running. Methods for testing chassis pickup were also outlined.

Moisture and Fungus

COMMUNICATIONS, electronics and associated electrical equipment is covered in a proposed standard specification JAN-T-152 recently issued with the date of May 26, 1945. Outlining the general process for treatment of products against moisture and fungus, the publication supersedes one dated March 23, 1945, as well as previous issues of Specification 71-2202-A.

Surplus Disposal

ELECTRONIC AND RADIO communication equipment of no further value to the armed forces is being disposed of through the Reconstruction Finance Corp. and more than 225 radio and electronic manufacturers who have accepted assignments to act as agents for RFC. Little of the equipment is expected to be sold in its original form. Some of the expected conversion includes, antennas into garden umbrella holders; mine detectors into divining apparatus; and tubular steel and plywood masts into flag poles.

Law-enforcing bodies, educational institutions and tax-supported organizations will be given preference in the sale of the equipment. By and large, the price setup will include: (1) electrically and mechanically perfect and unmarred units—new prices; (2) ditto but marred parts—slight reductions, and (3) ditto but battered parts—larger reductions.

Japanese Coverage

A RADIO STATION saved twenty Superfortresses, as well as the lives of 200 fliers and property worth more than $15,000,000. KSAI, a propaganda station located at Saipan is capable of concentrating the energy of five of the most powerful broadcasting stations in the U. S. toward Japan.

First, Japanese engineers tried unsuccessfully to jam it and the next night radio Tokyo urged its

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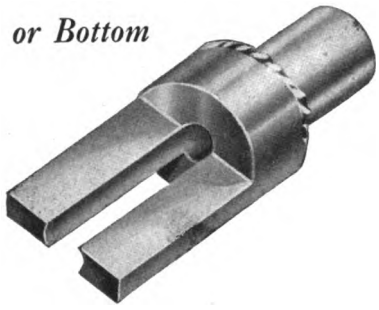
C. T. C. SPLIT TERMINAL LUGS

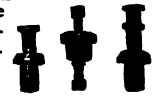
from Top or Bottom



A .050" hole through the shaft permits wiring from top or bottom side of the terminal board without time lost drilling holes. They're firmly anchored and swiftly set by a simple swaging operation. Knurling at base of Lug prevents twisting or turning.

C.T.C. SPLIT TERMINAL LUGS are particularly suitable for manufacturing transformers or other potted units requiring soldering after potting.

Stocked to fit ⅜" terminal boards —custom-made to your specifications in production quantities.



Write for C. T. C. Catalog No. 100

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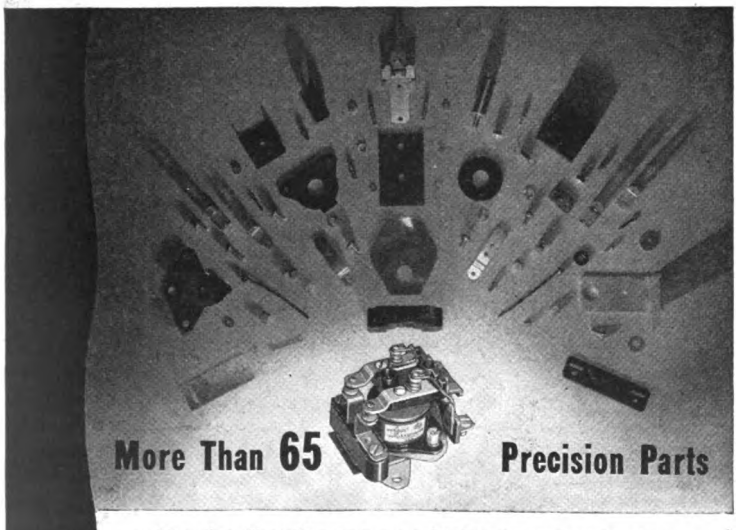

● More than 65 precision parts are used in the complex assembly of the average electric relay. Each of these parts must be precision-exact and the assembly must be perfect to give you consistent performance and lasting durability.

The entire engineering and manufacturing facilities of Potter & Brumfield Mfg. Co. are devoted to the manufacture of electric relays. This concentrated effort gives you precision manufacture and assembly that guarantees maximum relay performance.

Relays perform vital functions—it pays to buy the best! Write for complete catalog of Potter & Brumfield electric relays.

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Unlimited coding plus maximum insulation resistance

Spiralon, a new Surco plastic insulated wire, spiral striped, offers the widest range of tracer code identification in small as well as large sizes of wire, in short as well as long lengths. By avoiding use of color pigments, the primary covering retains full insulation resistance.

With Nylon Jacket

Spiralon reduces weight, permits a smaller OD., increases fungi and abrasion resistance, allows increased voltage, improves all electrical properties, eliminates all voids in the covering which ordinarily weaken such properties, resists creepage when terminals are being soldered or injury to wire insulation when accidentally touched by a hot soldering iron in production and overcomes deterioration from age. This high heat, low temperature non inflammable nylon jacket has already proved to be ideal for many applications.

A complete presentation on Spiralon is on the press. Please ask for your copy.

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Two-way conversation between headquarters, above, and bus driver, below, marks the first experimental installation of its kind. Bus, which belongs to the Washington, Virginia and Maryland Coach Co. will operate over 87 miles of company route and cover about 30,000 miles during the test to determine the improvements possible in bus service

ice. It will be used as a two-way communications medium between the bus operator and the company's headquarters in Arlington, Va., and parallels service of this kind in operation since earlier in the year between headquarters and the company's service and supervisors' cars.

IT&T Victory Development Conference

THE ANNUAL INTERNATIONAL conference of management and engineering personnel from International Telephone and Telegraph Corp. and its associated companies was resumed this year after more than five years of war activities had prevented such engineering get-togethers. Two weeks of techni-

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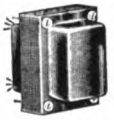

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Pri. tapped at 115, 117 and 120 V.A.C. Sec. output 850 V. at 200 ma. c. t. 4½" L x 3¾" W x 3⅞ W H. 5B5035.
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Hermetically sealed. Size, 1⅜" x 3". Can negative. Cap.: 40 mfd. at 475 volts; 15 mfd at 350 volts; 15 mfd at 150 volts; 20 mfd at 25 volts. 5B-3161 Each **59c**

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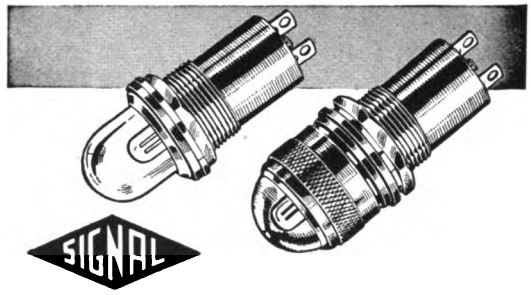

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cal sessions in the company's New York City headquarters were attended by delegates from Sweden, Belgium, France, England, Argentina, Holland, Denmark, Brazil, Spain, Norway, and Switzerland, as well as from the parent company and its affiliates in the United States.

Under the chairmanship of E. M. Deloraine, the conference program ran from Sept. 24 through Oct. 5 and included the following technical papers:

Various Methods of Modulation and Radio Relay Systems—Emile Labin
Long Distance Radio Communications—G. Rabuteau
General Technical Policy Relating to Instrument Landing, Air Traffic Control, Airways Navigation, and Long Range Navigation for Civil Aviation and Direction Finders—H. G. Busignies
Commercial Projects Relating to Air Traffic Control, Airways Navigation, and Long Range Navigation to Meet the Needs of Future Air Navigation—P. Adams
Some Characteristics of Triggered Circuits—A. H. Reeves
High Power Broadcasting—C. E. Strong
Dielectric Materials—A. J. Warner
Multiplex Systems of Frequency Modulation—A. Clavier
Modern Carrier Systems—A. W. Montgomery
Wire Transmission—R. E. Smith
Machine Switching Systems—W. Hatton
Record Communication Systems—A. E. Thompson
Patents—R. J. Berry
Telephone Traffic Analysis by Automatic Means—Jakob Kruithof

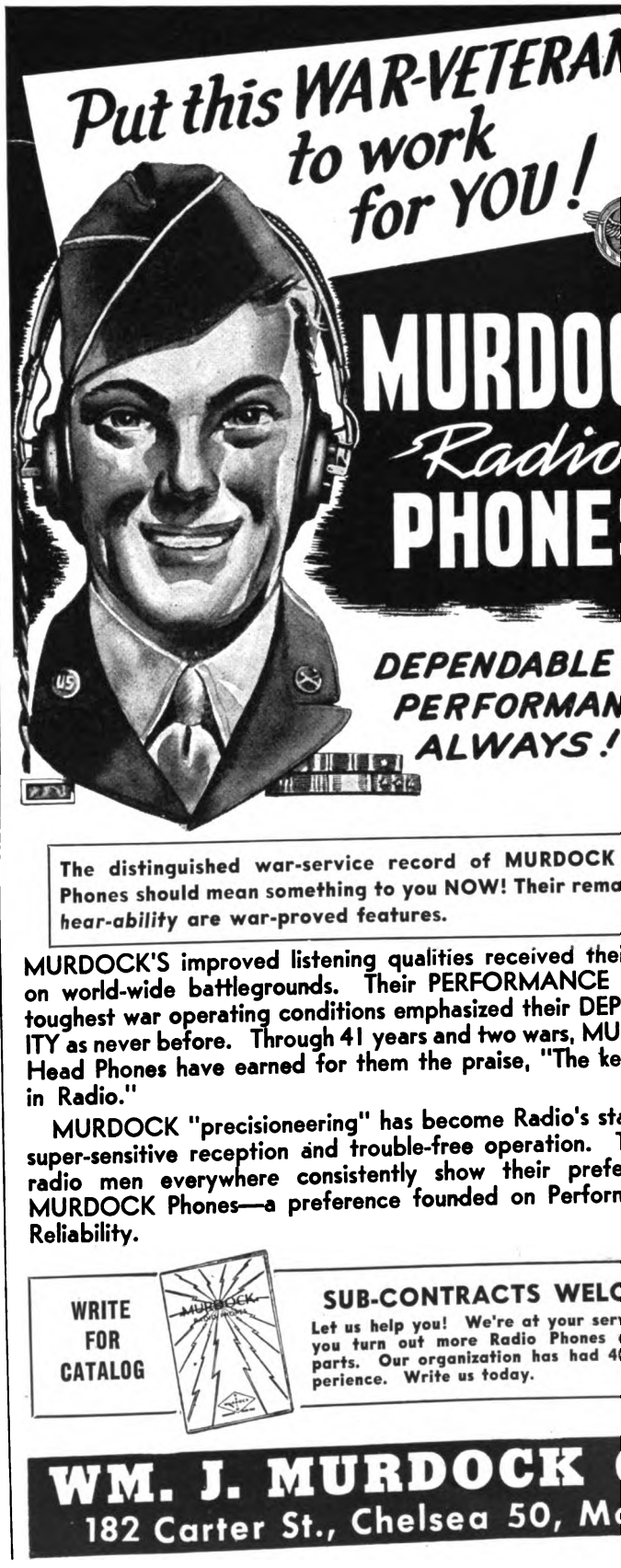
A feature of the conference was the first non-secret demonstration of pulse time modulated multiplex telephony on microwaves (for details, see Tubes at Work department in this issue), along with demonstrations of new direction finders and other electronic devices.

Educational Trends

AT THE POLYTECHNIC Institute of Brooklyn, the first institution in the country with a graduate program in microwave technique, the electrical engineering curriculum has been revised to include a series of courses based on unclassified war developments. The undergraduate will be faced with two options: (1) electrical power and industrial applications and (2) electronics and communications.

Beside the usual work on electrical machinery and power transmission, the first option will include courses on industrial control and industrial electronics. Option number two provides a revised curriculum to include recent developments in uhf and its application to f-m and television.

On the graduate level there is an extensive program in microwaves—



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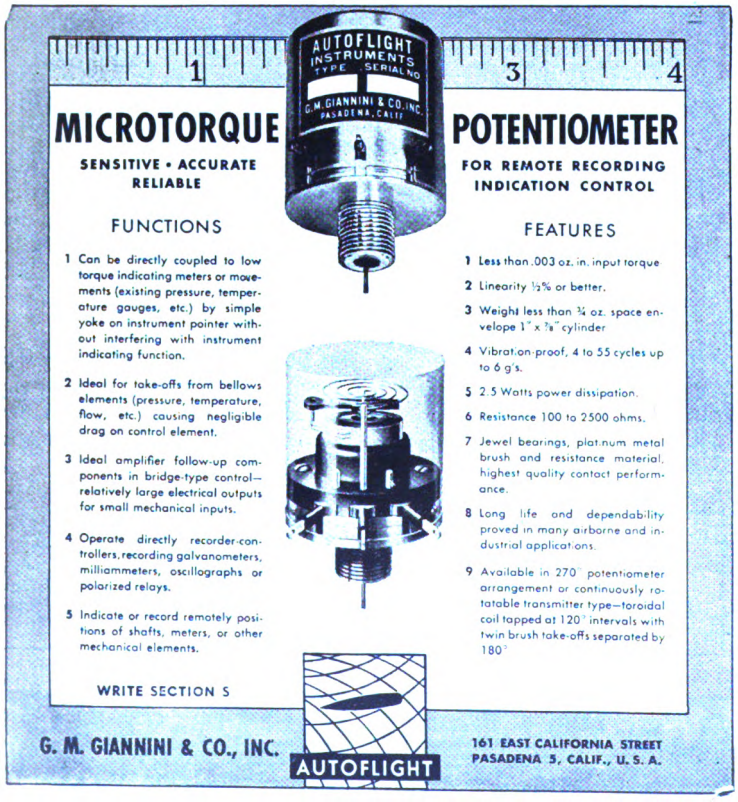

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2 Ideal for take-offs from bellows elements (pressure, temperature, flow, etc.) causing negligible drag on control element.

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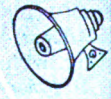

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generation, transmission, reception in all phases, servo mechanisms, antennas, television, modulation circuits, and electron optics.

At New York University's College of Engineering, a normal schedule of two 16-week semesters a year has been reinstated. It supersedes an accelerated program which had been in effect since October 1943, but a full year will be required before all students will be back on normal schedule.

Wartime Radio-Radar Production

FIGURES SUPPLIED by the Radio and Radar Division of WPB reveal that the industry produced approximately $7.5 billion worth of goods during the war. Following are figures provided in an annual breakdown by WPB:

	Monthly	Total
1942		
Jan.—June	$55,000,000	$330,000,000
July—Dec.	109,000,000	654,000,000
1943		
Jan.—June	166,000,000	960,000,000
July—Dec.	200,000,000	1,200,000,000
1944		
Jan.—Dec.	223,000,000	2,676,000,000
1945		
Jan.—Aug.	200,000,000	1,400,000,000
		$7,220,000,000

Additional production, principally during the September-December period in 1941 accounts for the other $330,000,000.

Intercity-Bus Radio

A DIVISION of the National Association of Motor Bus Operators called Intercity Bus Radio Inc. is seeking permission from FCC to equip up to 100 intercity buses with two-way radio communication and to operate a central control transmitter. The 250-w central transmitter would be located in the Chicago Loop, while the buses would be equipped with 50-w transmitters and with receivers. Three additional relay receiving stations would be located in outlying sections of Chicago.

It is anticipated that the central transmitter would be able to reach buses as far distant as 75 miles. Frequency modulation would be used and operation would be on two frequencies between 30 and 44 mc.

Greyhound Corp. is undertaking the experiment in cooperation with

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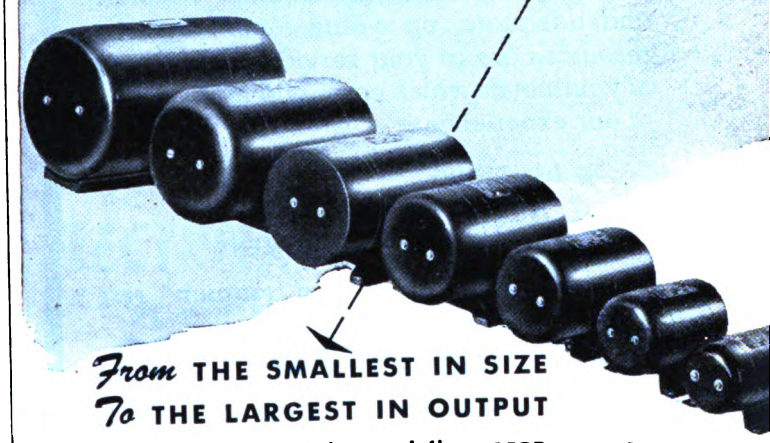

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2700	15	2 3/4 in.	4 3/4 in.	2 3/4 lbs.
3400	125	3 7/16 in.	5 5/8 to 8 11/32 in.	4 1/2 to 7 1/2 lb
4100	200	4 1/16 in.	6 1/2 to 7 3/8 in.	6 3/4 to 9 lbs.
4500	250	4 1/2 in.	6 1/2 to 8 in.	11 1/2 to 13 1/4
5100	350	5 1/8 in.	8 1/2 to 10 in.	17 to 21 1/2 l
6100	500	6 3/16 in.	9 5/8 to 12 in.	28 to 36 lbs.

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MEETINGS TO COME

Nov. 2; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Radar Generation; Engineering Auditorium, 33 West 39 St, New York, N. Y.; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

Nov. 8; INSTITUTE OF RADIO ENGINEERS, New York Section; Radio Pioneers' Party; Commodore Hotel, New York, N. Y.; by ticket ($6.) from E. J. Content, WOR, 1440 Broadway, New York, N. Y.

Nov. 9; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Radar Reception; Engineering Auditorium, 33 West 39 St, New York, N. Y.; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

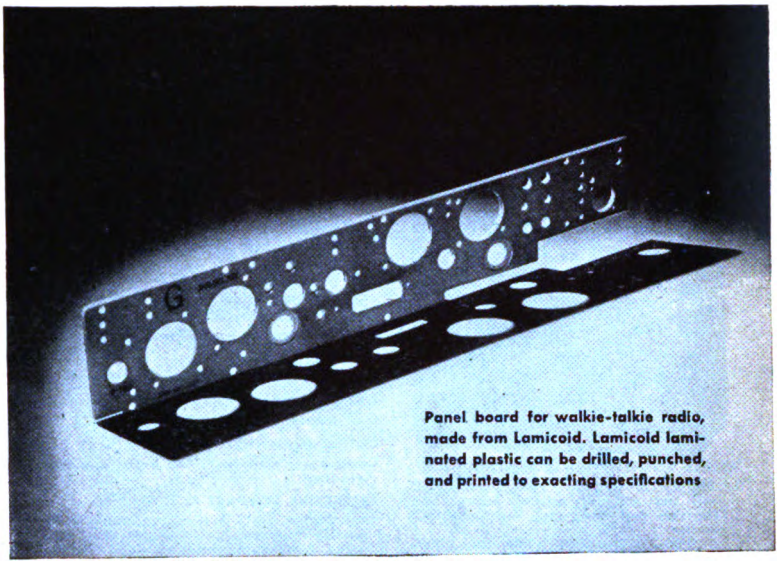
Nov. 12-13; ROCHESTER FALL MEETING COMMITTEE, Rochester Fall Meeting; Sheraton Hotel, Rochester, N. Y.; Virgil Graham, chairman, P. O. Box 750, Williamsport, Pa.

Nov. 12-15; INTERNATIONAL MUNICIPAL SIGNAL ASSOCIATION, 50th annual meeting; Hotel La Salle, Chicago, Ill.; Irvin Shulsinger, secretary, 8 East 41st St., New York 17, N. Y.

Nov. 13; INSTRUMENT SOCIETY OF AMERICA, New Jersey Section; Instrumentation in the Industrial Power Plant by Julius G. Berger, consulting engineer; Essex House, Newark, N. J.

Nov. 14; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Survey of the Servomechanism Field, by Gordon S. Brown, professor, Massachusetts Institute of Technology; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

Nov. 16; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Radar Indication; Engineering Auditorium,



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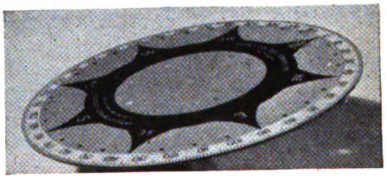

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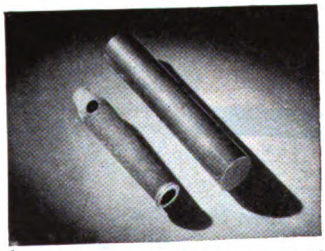

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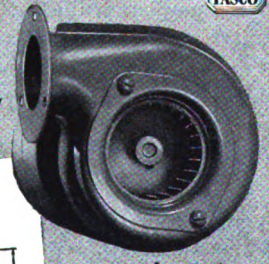

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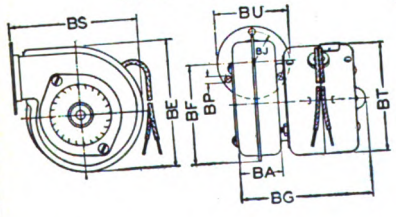

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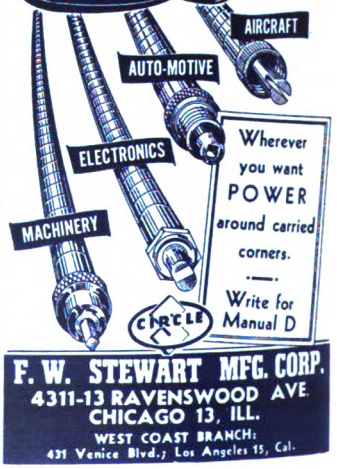

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Nov. 23; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Radar Testing Equipment; Engineering Auditorium, 33 West 39 St, New York, N. Y.; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

Nov. 27; INSTITUTE OF RADIO ENGINEERS, Cedar Rapids Section; Oscillators, by Professor W. L. Cassell, Iowa State College; J. A. Green, secretary, Collins Radio Co., 855 35 St, N. E., Cedar Rapids, Iowa.

DEC. 12; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Mathematical Formulations for Linear Servomechanism Systems, by Charles F. Rehberg, New York University; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

JAN. 9; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Transient Analysis of Linear Servomechanisms, by John R. Ragazzini, professor, Columbia University; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

JAN. 18-FEB. 7; GARDNER DISPLAY CO., Products of Tomorrow Exposition; Coliseum Group, Chicago, Ill. Marcus Hinson, general manager planning department, Armory, 16th and Michigan, Chicago.

JAN. 23-26, INSTITUTE OF RADIO ENGINEERS, 33d Annual Winter Technical Meeting; Astor Hotel, New York, N. Y.; E. J. Content, chairman of meeting committee, WOR, 1440 Broadway, New York 18, N. Y.

WASHINGTON NEWS

RAILROAD OPERATORS. The 500,000 railroad employees who are eventually expected to be involved in the operation of railroad radio equipment will not be required to have operating licenses from FCC, according to a recent rule of that body. In lieu of its waived examinations, the Commission

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Now Available To You
TO ASSIST YOU WITH YOUR PROBLEMS OF
DESIGN
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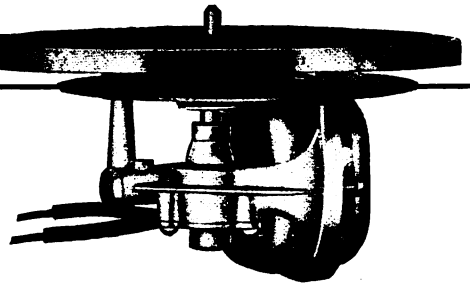

General Industries constant-speed electric phonograph motor—Model CX.

Users and the trade have always given hearty applause to General Industries phonograph mechanisms. Owners like the fine fidelity of every note or syllable—and sales and service departments are strong for their reliability and freedom from maintenance troubles.

You get this same old-time satisfaction from our *Smooth Power* turntable motors, recording assemblies and record-changer recorder combinations as we return to civilian production. As always, General Industries equipment will earn your approval.

THE GENERAL INDUSTRIES COMPANY
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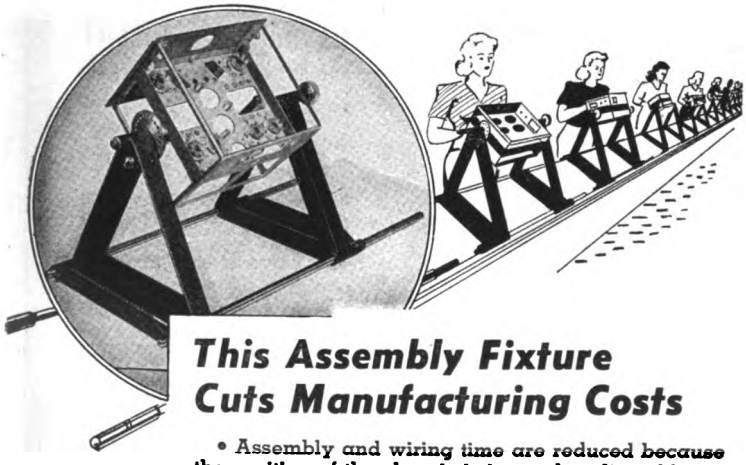

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• One fixture investment serves for all models since each fixture is adjustable to various chassis sizes.

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approved a procedure where applicants will be required to pass an examination conducted by railroad examiners.

INDUSTRIAL EMPLOYMENT. At the peak of activity last spring, the radio industry had a personnel of more than 500,000, according to WPB. By July, this had fallen to 470,000. Estimates have it that 335,000 people were obtained from the prewar radio industry itself, while the rest were newcomers, many of whom are expected to go back to other pursuits in peacetime production.

COMPONENTS. WPB is predicting the possibility of 3,500,000 new radio sets for civilian use by the end of the year. Supplies of components will be ample to meet most needs of the industry, and while some items may be in short supply, there are many cases where substitutes can be used. Besides this, quantities of components can come from surplus stock and also from longer production runs made possible by the less precise specifications of civilian designs. Component supplies for military and civilian research and development laboratories have become so easy that ERSA (Electronics Research Supply Agency) is scheduled to go out of existence. Component production capacity has increased markedly during the war, as may be seen from the following table:

Component	1939 Average Monthly Production	June 1945 Deliveries
Tubes (receiving)	9,127,000*	13,117,000*
Tubes (receiving)	$3,747,000	$6,380,000
Tubes (transmitting)	27,000*	2,412,000*
Tubes (transmitting)	$189,000	$15,960,000
Transformers	$706,000	$13,090,000
Capacitors	$3,293,000	$13,022,000
Resistors	$770,000	$7,429,000

* Units

FCC ACTS

To permit:	To do this:
WSAP Portsmouth, Va.	Operate with newly installed vertical antenna.
WOMT Manitowoc, Wis.	Operate with increased power and changed transmitting equipment.
KOTA Rapid City, S. D.	Operate with changed frequency, power increase, new transmitter and directional antenna for night use, and transmitter moved.
WHNC Henderson, N. C.	Operate newly constructed standard broadcast station.
WHBC Canton, Ohio	Use formerly licensed 250-w transmitter as auxiliary.
WATX Ann Arbor, Mich.	Extend completion date of new non-commercial educational broadcast station to December 16, 1945.
WJBK Detroit, Mich.	Install composite 250-w transmitter at present site of main transmitter for auxiliary.

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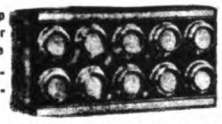

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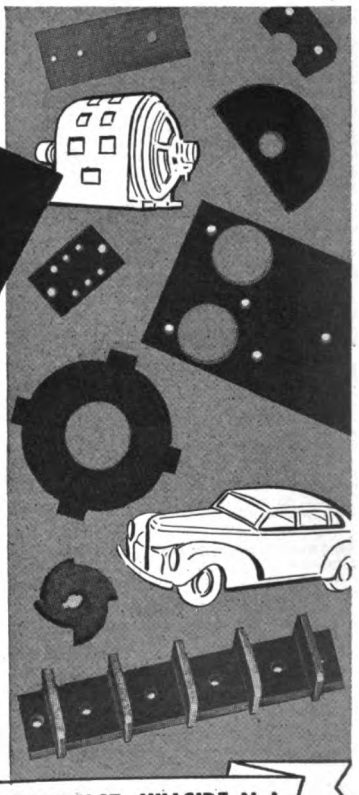

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WLEE Richmond, Va.	Modify construction of new station to install vertical antenna and change transmitter location.
Michigan Bell Telephone Co. Detroit, Mich.	Construct experimental Class 2 coastal harbor station for ship-to-ship and ship-to-shore radio telephone communications on vhf. Frequencies will be assigned, power will be 60 w.
Illinois Bell Telephone Co. Chicago, Ill.	Same as above.
Lorain County Radio Corp. Duluth, Minn.	Same as above.

BUSINESS NEWS

SHERRON ELECTRONICS Co. Brooklyn, N. Y. is set up to provide an electronic engineering service for manufacturers having problems where electronic devices and applications may aid. It covers the complete research, design, development, and manufacturing service.

MAGUIRE INDUSTRIES INC., Bridgeport, Conn., is retooling its tommy gun plant for production of railroad radio equipment, a 6-tube home receiver, an automatic record changer and related items.

WESTERN ELECTRIC Co., New York, N. Y., supplied to the Government during the war more than 52,900 radars of 64 different types valued at more than $800 million.

PERSONNEL

NORAN E. KERSTA, former manager of NBC's television department has been discharged from the U. S. Marine Corps. He returns to the network's television department in an executive capacity.

CHARLES R. DENNY, JR., former general counsel to FCC, is confirmed in his membership on the Commission. He is the youngest commissioner in FCC history.

RAY C. ELLIS, former director of the WPB radio and radar division, is appointed vice-president of Raytheon Mfg. Co., New York, N. Y.

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You will want to use and know more about these new sub-miniature vacuum tubes

Actual *Size*

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15 ma., 1.5 volts

Grid current less than 10^{-14} amperes—grid resistance approximately 10^{16} ohms.
Individually checked for uniformity within the range of the best operating characteristics—each tube is built for exacting circuit requirements.

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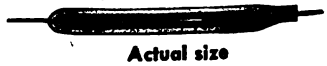
And now in production—new hi-meg vacuum sealed resistors in a range never adequately covered before—values from 1 megohm to 1,000,000 megohms. Write for literature on tubes and resistors or consult us on your tube problems.

1,000,000 Megohms



Actual size

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know more about
new sub-miniature
uum tubes

Actual

-Series VW-
15 ma., 1.5 vo

Grid current less
10^{-14} amperes—grid
sistance approx
10^{16} ohms.
Individually checked
uniformity within
range of the best
ing characteristics—
tube is built for exact
circuit requirements

Available as...
Electrometers
Pentodes
Tetrodes
Triodes
Diodes

And now in
—new hi-mu vacuum
sealed resistors in
range never adequately
covered before—
from 1 megohm
1,000,000 megohms
Write for literature
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Actual size

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November 1945—ELECTRONICS

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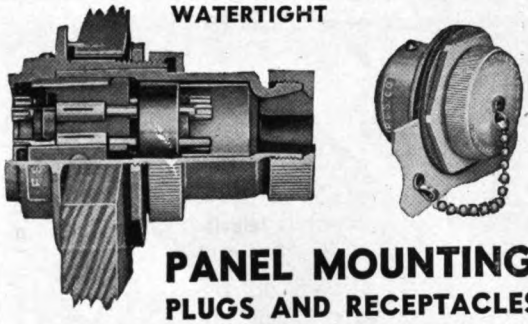

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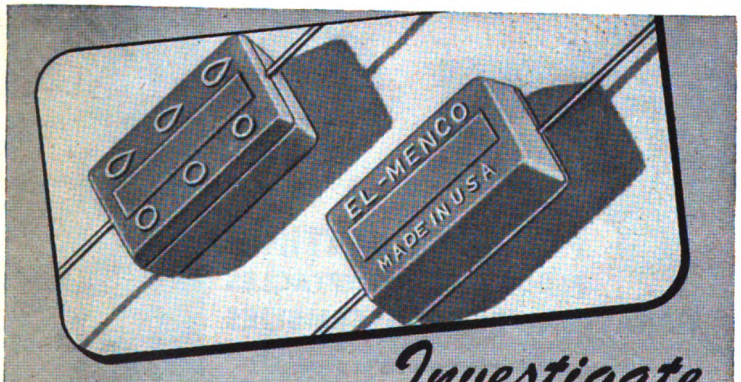
HUGH S. KNOWLES, vice-president and chief engineer of the Jensen Radio Mfg. Co., Chicago, Ill., is elected president of the Acoustical Society of America.

JAMES H. MCGRAW JR., chairman of the board and president of McGraw-Hill Publishing Co. is awarded the honorary degree of

doctor of engineering, "for his achievement in behalf of science and engineering for their fullest use for all the peoples of the world," by Rensselaer Polytechnic Institute, Troy, N. Y.



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- ELECTRO MOTIVE MANUFACTURING COMPANY—Molded Mica Capacitors . . . Mica Trimmer Capacitors

Four miniature tubes are used as the full electronic complement of the proximity fuze described in detail elsewhere in this issue. The fuze includes a triode, two pentodes and a thyratron. They are being held by Roger M. Wise, vice president and chief engineer of Sylvania Electric Products, the company which made all the tubes for use in rotating projectiles. One-ounce tubes, mounted in the projectile assume a weight of 125 lb under acceleration of being fired from guns

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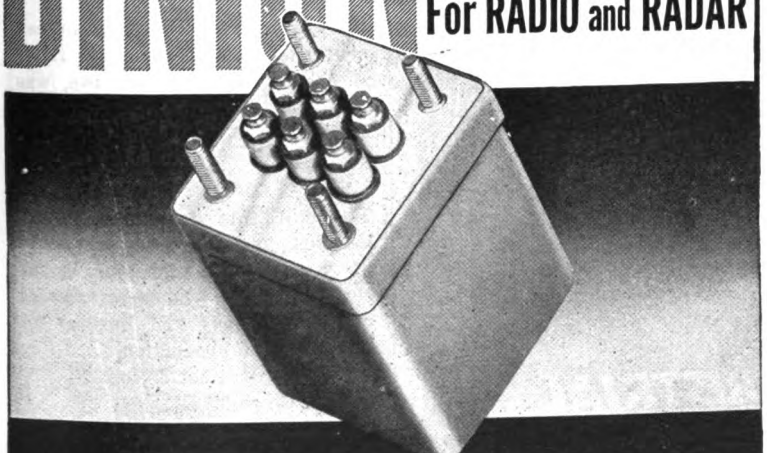

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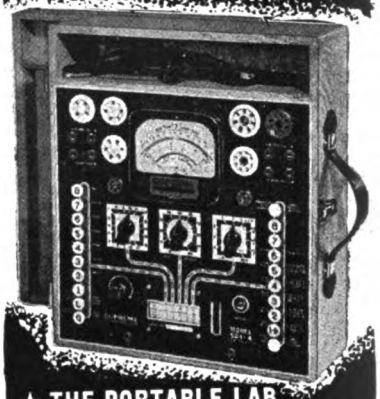

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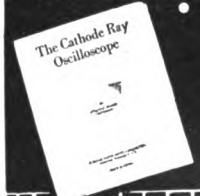
★ Guaranteed Rectifier.

SPECIFICATIONS

DC MICROAMPERES: 0-500
DC MILLIAMPERES: 0-2.5-10-50-250
DC AMPERES: 0-1-10
DC VOLTS—1000 OHMS PER VOLT: 0-5-25-100-250-500-1000-2500
AC VOLTS: 0-5-10-50-250-1000
OUTPUT VOLTS: 0-5-10-50-250-1000
OHMMETER: 0-200-2000-20,000 OHMS 0-2-20 MEGOHMS
BATTERY TEST: Check Dry Portable "A" and "B" Batteries Under Load
CONDENSER CHECK: Electrolytics checked on English Reading Scale at Rated voltages of 25-50-100-200-250-300-450 volts.
TUBE TESTER: Emission type with noise test floating filaments, easy chart operation. Checks all receiving type tubes.
POWER SUPPLY: 115 volts 60 cycle. Special voltage and frequency upon request.



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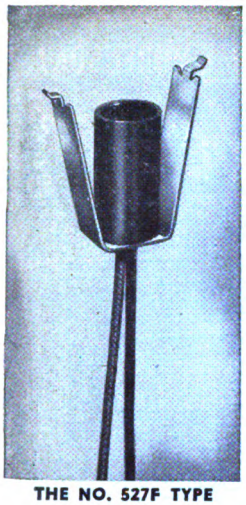

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- √ Center contact lead wire mechanically secured before soldering.
- √ Both lead wires withstand over 25 lbs. tension.
- √ Rounded eyelet edges prevent cut or frayed lead wire insulation.
- √ 1000 volts minimum breakdown voltage between contacts and to ground.
- √ Casting mechanically secured to bracket — can't turn.
- √ Socket mechanically secured within casting — can't turn or be pulled out.
- √ Center contact secured within socket — contact won't protrude when lamp removed.

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One of America's AAAA Industrial Enterprises

ROY S. KERCHER is appointed chief electrical engineer at Grayhill, Chicago, Ill. He was previously with the Furnas Electric Co. engaged in laboratory and experimental work.

ROBERT A. MILLIKAN, 77, administrative head of the California Institute of Technology for 24 years, retires. He will continue as vice-president of the board of trustees and will assist the board president in public relations and institutional development. In 1923 he was awarded the Nobel Prize in physics for isolating and measuring the charge of an electron.

RAY H. MANSON, who joined Stromberg-Carlson Co. in 1916 as chief engineer, becomes the first engineer-scientist to be president of the company during its 51 years.

He has been executive vice-president and general manager. He is succeeded by LEE MCCANNE, who originally joined the firm as a radio engineer.

AWARDS

THROUGH this department ELECTRONICS pays tribute to the workers of the following concerns in the electronic field who were awarded final Army-Navy "E" burgees for excellence in production.

John E. Fast & Co.
Chicago, Ill.
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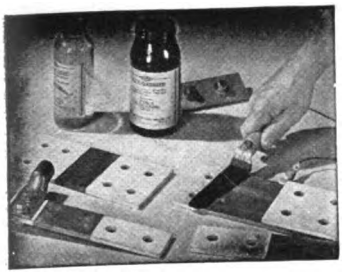

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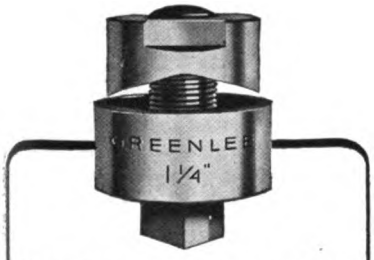

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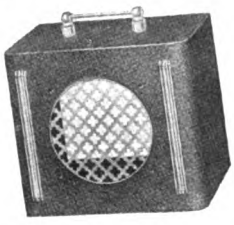

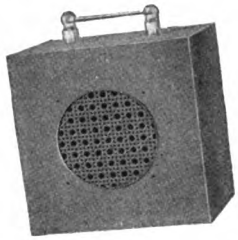

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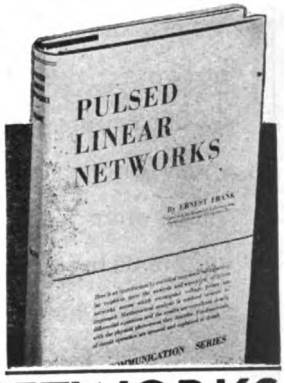

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Network Analysis and Feedback Amplifier Design

By HENDRIK W. BODE, *Research Mathematician, Bell Telephone Laboratories. D. Van Nostrand Co., Inc.*, 1945, 551 *pages*, $7.50.

BASIC CIRCUIT THEORY and mathematical analysis of feedback amplifiers is presented in generalized form for the design engineer. The text is self-contained for those who have had the equivalent of present-day college senior circuit and mathematics courses. The discussion is interspersed with practical circuit considerations and conclusions. Stress is laid on interpretation of circuit behavior from graphs of circuit functions.

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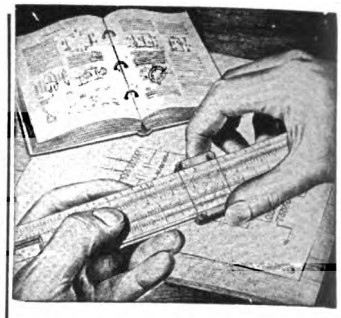

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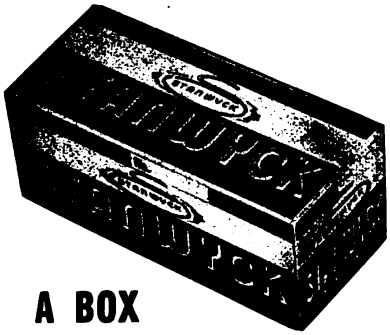

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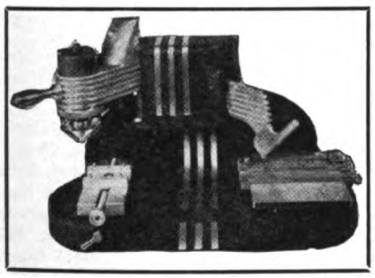

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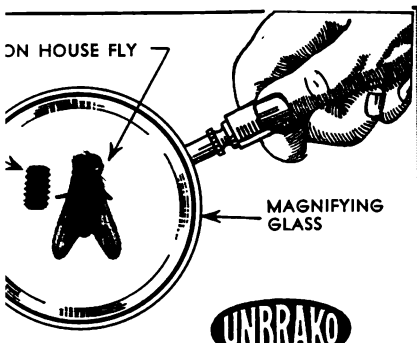

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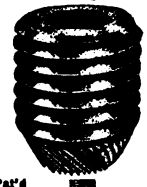

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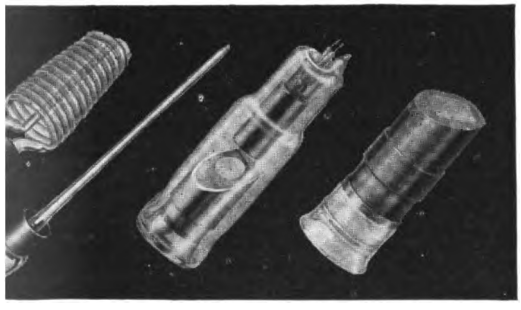

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By HENRY DEWOLF SMYTH, *Chairman, Department of Physics, Princeton University, and Consultant, Manhattan District, U. S. Engineers. Published by the Princeton University Press, Princeton, N. J., 1945, 264 pages, paper bound* $1.25, *cloth bound* $2.00.

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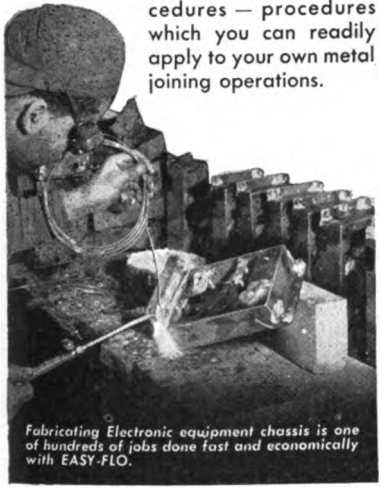

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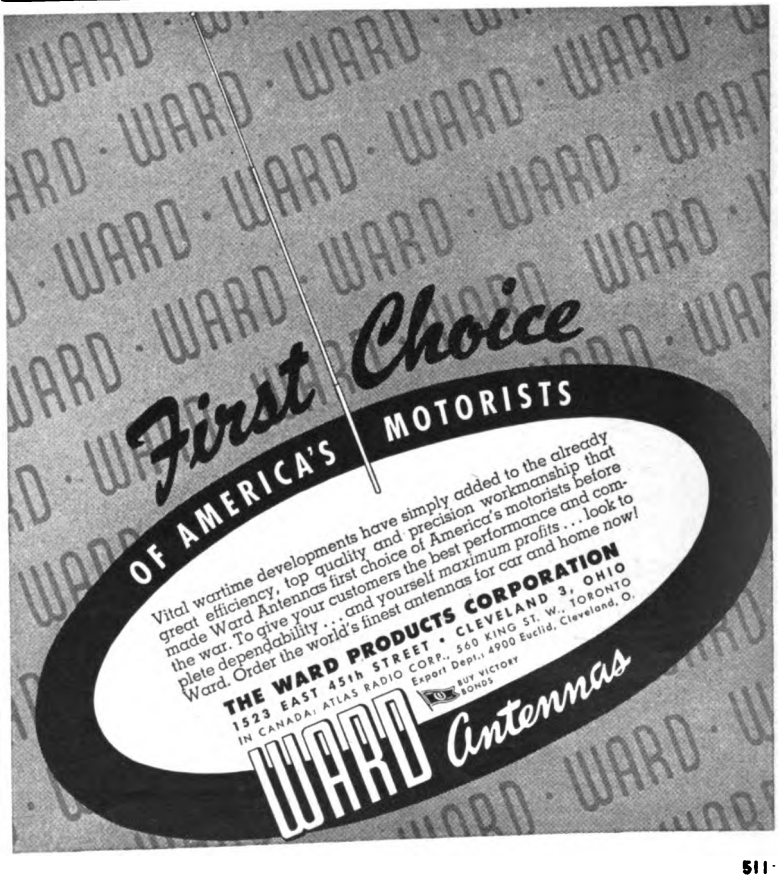

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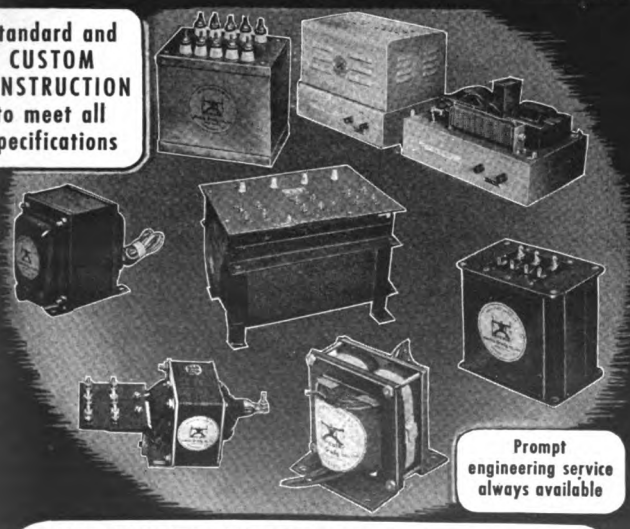

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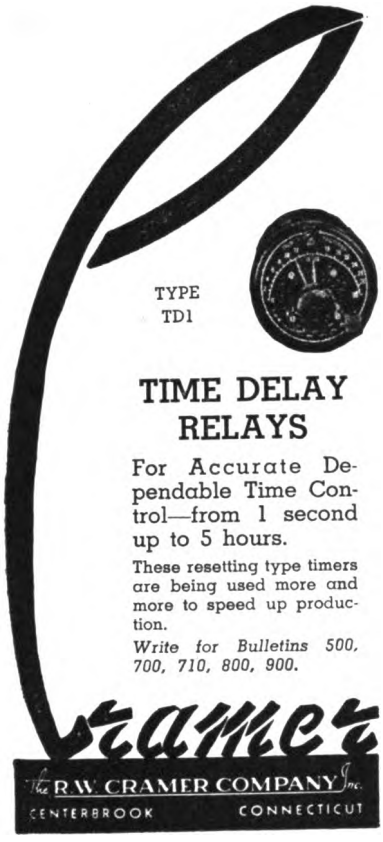

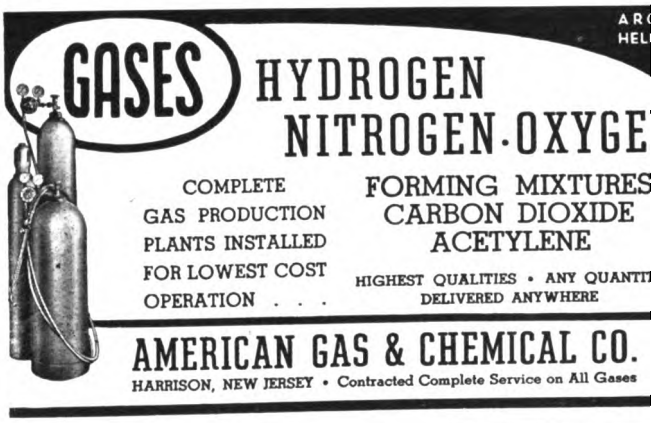

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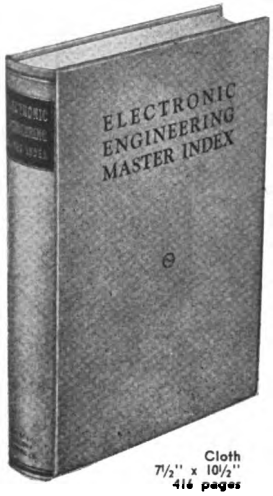

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By GEORGE H. FERN, *Director, Michigan State Board of Control for Vocational Education. McGraw-Hill Book Co., New York, 18, N. Y., 188 pages, $2.00.*

A TEXTBOOK MANUAL aimed at guiding the supervisor in his own self-improvement and upgrading, helping the prospective supervisor, and helping conference leaders to get results. Human relations receive major attention because to many workers the supervisor is the company and by his actions the company is judged. Other topics covered include accident prevention, women in industry, starting the new worker, and job analysis.—J.M.

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By RICHARD W. WETHERILL. *National Foremen's Institute, Deep River, River, Conn., 16 pages, $0.25.*

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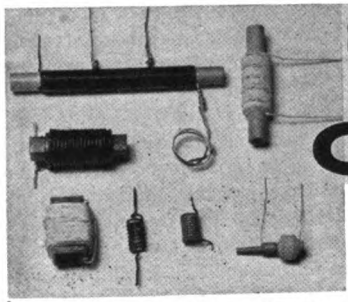

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bility to provide leadership that will hold up the spirit and morale of his men. Three main steps in learning to handle various personalities are outlined: (1) Adjust your own personality; (2) Know your workers; (3) Lead properly. A good refresher for supervisors. —J.M.

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Transmission Lines, Antennas and Wave Guides

By RONALD W. P. KING, HARRY ROWE MIMNO, *and* ALEXANDER H. WING, *all of Harvard University. McGraw-Hill Book Co., Inc.*, 1945, 347 *pages*, $3.50.

FROM EXPERIENCE in training commissioned officers in new uhf applications of electronics, the Cruft Laboratory faculty has prepared this descriptive text. The treatment employs a minimum of mathematics, chiefly trigonometry and complex algebra. For the most part the discussion concerns the physical behavior and practical uses of representative uhf circuits. Information and concepts are summarized in graphs and line drawings. At the end of the book there are problems with answers.

Among specific topics on transmission lines likely to be of especial interest are: means of suppressing even harmonics and suppressing the third harmonic; impedance matching by quarter- and half-wave sections and by either single or double stubbing; construction and use of a circle diagram for calculating stub lengths and positions.

Distribution of current and voltage on antennas is explained, with illustrations for a variety of antenna elements. Methods of feeding the different types of elements are described, with the purpose of each. Phasing and coupling of parasitically excited arrays are shown. The section concludes with determinations of the fields of antenna arrays, and mention of the familiar antenna systems.

In the chapter on wave guides the behavior of guides and the modes in which they can operate are analysed descriptively. From the understanding so acquired, methods of driving guides and the configurations of cavities are developed.

The last chapter on wave propagation describes briefly the principal factors affecting wave propagation.—F.R.

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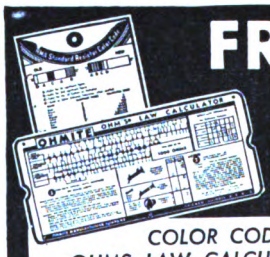

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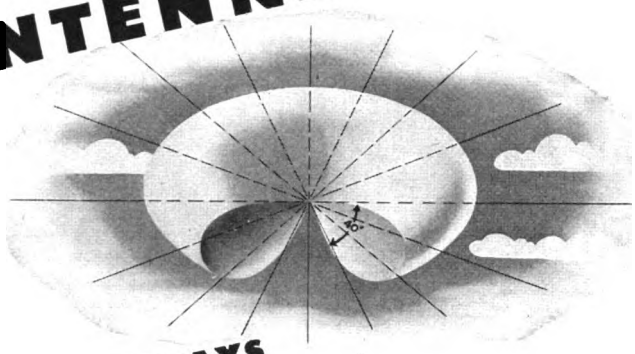

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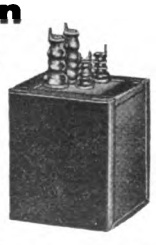

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the Royal Navy in Britain producing radar equipment for the fleet, and have just recently returned.

ELECTRONICS magazine, as you only too well must know, is very much in demand overseas especially in such establishments as this. We could manage to get just one copy per month and to circulate it adequately some three to four hundred of us put our names on the circulation list.

I can tell you the poor thing looked like just a pile of reference sheets by the time it got around; needless to say it was in circulation for a good eight months before we had all seen it. The only way we could get any permanent information from it was to have photostat copies made of each useful and relevant article; those copies were certainly very much in demand. Will the day come when ELECTRONICS is easily available!

Being the only American on the staff, I was continuously being asked to interpret words, terms, and advertisements. I found the experience very interesting.

ROBERT L. WOLTZ
Wichita, Kan.

[The day has come; ELECTRONICS is back on a normal circulation basis.—Ed.]

• • •

GRID PROJECTION

The 813 transmitting tube has two grids which must be perfectly aligned. At North American Philips, light is projected on the tube mount and then focussed on a ground-glass plate. The 20-to-1 enlargement produced shows whether or not one grid is exactly behind the other

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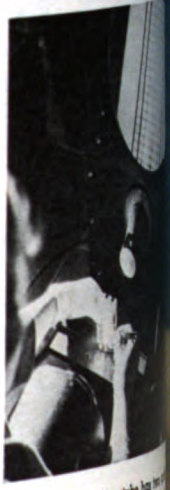

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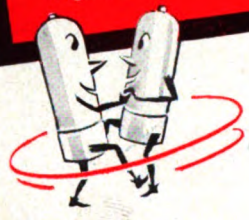

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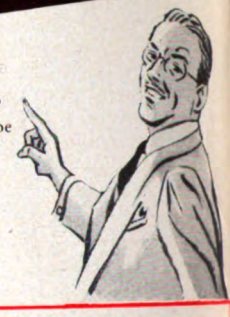

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MICROWAVE RADAR ..... Cover

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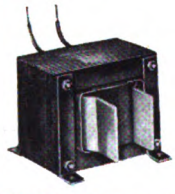

CONDENSER–PULSE WELDING TRANSFORMER

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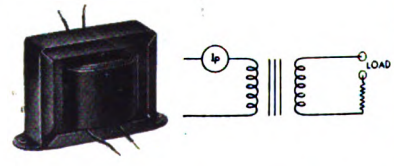

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CROSS TALK

▶**HEAT** . . . Electronic heating gets up into the high power regions where a potential user of the equipment naturally wants to know how much juice he must put in and pay for. His curiosity concerning how much he is going to get out is also natural.

In the case of motor-generator equipment, the horsepower rating of the driving motor and the kw output of a high-frequency generator are established by well-recognized and standardized testing procedure. In the case of the spark-gap or vacuum-tube oscillator, however, the kw output available for heating is not as readily measurable by the usual electrical means.

This may account for some of the efficiency figures we see quoted by manufacturers of spark-gap and tube heating equipment; certainly the situation calls for some quick standardization by the several bodies interested in such matters.

Speaking of tube-type machines, the plate efficiency of an oscillator will seldom exceed 65 percent and when one takes into account the tank losses, transformer losses, filament losses and other wastages of power, the overall ratio between output and input cannot be greater than one-half and is quite likely to be below.

Standard methods of measuring electronic heating efficiency and of rating this important quantity are urgently needed.

▶**BOMB** . . . One of our imaginative broadcast stations phoned the atomic bomb people a day or so after the New Mexico trial explosion to request the Army to shoot off another bomb so that a sound-effects record could be made.

And incidentally, there were only two violations of security regarding the Kellex Corporation, one before VJ day by a broadcast station and one after the war's end by a national magazine of news comment.

▶**MORE TALK** . . . Most present criticism of broadcast programs is on two points, advertising blurbs, and serials. Now this is just a hunch, but maybe this criticism is really against the great amount of talk on the air. Maybe people really want more music. Any casual turning on of the radio at practically any station at any time of the day will produce talk. If the listener wants music he must know when to get it, and, of course, even when he gets his music he must put up with a great deal of talk.

CBS has made a study of the serial situation to find out who listens to them, who likes them, and how much. Taking a typical Wednesday in Dubuque, CBS charted the situation from eight in the morning to six in the evening. In this day there were 40 quarter-hour periods and on this particular day listeners in Dubuque could tune to an average of about eight or nine stations at any particular moment. There were actually 347 individual programs during that time, 93 of them being music.

The listener who merely snapped on the radio had only a 27 percent chance of finding music and casually turning on the radio would result in a 73 percent chance of getting into the midst of a talk program. Considering that there was an average of 8 or 9 stations operating at any one time, the listener who wanted music would have to do a lot of hunting. After he had pushed several buttons or had dialed to several stations and found talk, he would probably turn the radio off and forget about it.

So far as serials are concerned, there were 51, and if you were serious you could listen to serials solid from nine to five except for a 15-minute period after lunch. During the rest of the time there were one, two or even three going on at once.

P.S. CBS's survey indicates that people like serials.

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Fire-Contro

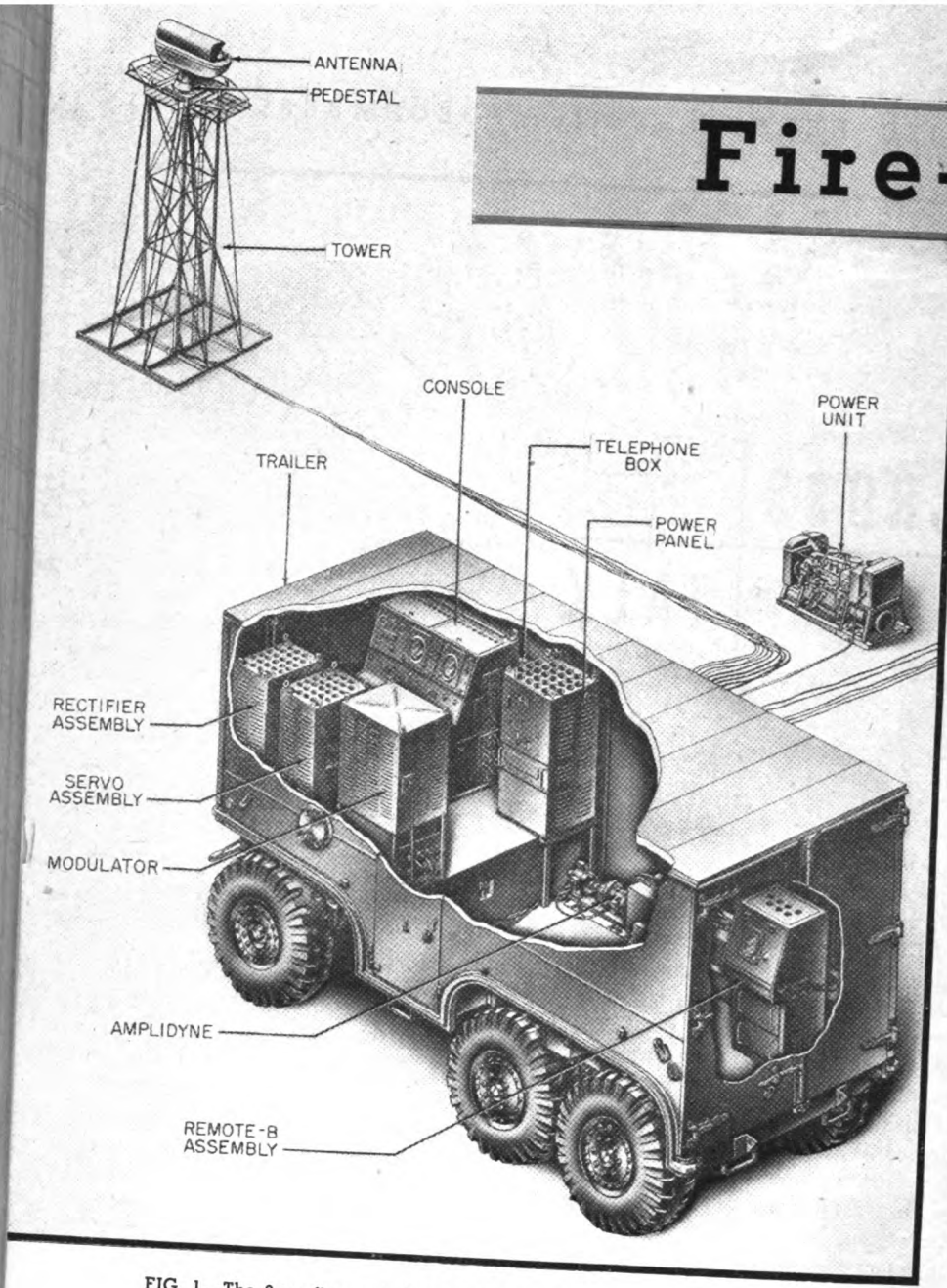

FIG. 1—The 3-cm fire-control radar AN/MPG-1, showing the trailer, power unit and antenna in operating position. The setup is adjacent to a gun battery, usually near a harbor or along a coastline

THE ALLIES faced a serious military situation in the spring of 1942. Attacks on important American harbors by PT boats were considered possible. At that time, no radar existed which could adequately detect and track these small, fast, maneuverable craft. So the Coast Artillery Board on the 20th of May set up characteristics for a radar which could supply position data on PT boats to a data computer for seacoast gun batteries.

Meanwhile, the National Defense Research Committee, with funds supplied by the Office of Scientific Research and Development, had begun to study the problem of supplying fire-control data to major-caliber guns at the Radiation Laboratory at M.I.T. When, therefore, in August 1942, the Signal Corps submitted the anti-motor-torpedo-boat project to NDRC for development, progress already had been made.

The Radiation Laboratory prototype set was assembled in form and de-bugged by th of November, 1943. Aft days operation at a station ton harbor, the set was tran to a Coast Artillery test site Story, Virginia.

A few months before co of the prototype model, the Corps became interested in for use with their seacoast ar This led to a revised unit, the AN/MPG-1, which is ho a trailer van made water-ti to the roof.

General Design

When in use, the AN/MP set up as shown in Fig. 1, ov ing the harbor or coastlin meant to defend. Capable o placed in operating condition hours after selection of a si radar can begin its tactical tions by the time the gun b is installed. Present-position on any designated target are mitted to the battery comma where the information is directly into a computer which plies firing data to guns, or is to furnish data for a plo board course of the target which its future position is dicted.

The technical characteristics the AN/MPG-1 are given in Ta

Because of the narrow be width, dipole (window) jam of the set is not readily ac plished. The resolution is that at 20,000 yards two destro separated by 300 yards of water are seen as separate targ on the tracking scope. This resolution enables skilled opera to track targets readily thro heavy concentrations of sh buoys, islands and floating wr age, with minimum danger tracking the wrong target.

The high accuracy of majo caliber seacoast weapons dicta certain features of design. Hig resolution and extreme accura

electronics WAR REPORT

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dar MPG-1

lescription of microwave radar operating on 3 cm with sufficient speed and accu- enable coast artillery to hit maneuvering PT boats. Control of harbor traffic in me is suggested by the design. Further details will follow in subsequent articles

By H. A. STRAUS, L. J. RUEGER, C. A. WERT
Radiation Laboratory, Massachusetts Institute of Technology, Cambridge, Mass.

and S. J. REISMAN, M. TAYLOR, R. J. DAVIS, J. H. TAYLOR
Radio Division, Bendix Aviation Corp., Towson, Md.

uired in both range and Resolution requirements small angular divergence eam. The antenna system orizontal direction had to in terms of wavelengths. , angular position had to trolled very accurately. he moment of inertia of bodies increases as the fifth f the size, it was not prac- increase too much the size antenna assembly carried azimuth drive system. Very problems were presented by uirements of the servo sys- hich controls antenna posi- Tracking had to be smooth curate to within 0.01 deg at g speeds of less than 0.01 more than 1 deg per second. was decided to employ an cal method of antenna scan than to try to oscillate a mass physically. The scan had to be frequency-insensitive to assure accurate pointing of the beam, regardless of variations in characteristics of different transmitter tubes. A stigmatic optical system without spherical aberration had to be built having wide field, high speed, compactness and freedom from coma. It was necessary also to develop a modulator capable of being very accurately triggered and delivering a 0.25-microsecond pulse to the magnetron, with accurate control of the pulse rise and decay time. To achieve maximum range resolution permitted by the pulse length, a broadband i-f strip (approximately 10 mc bandwidth) and video circuits had to be developed for the receiver.

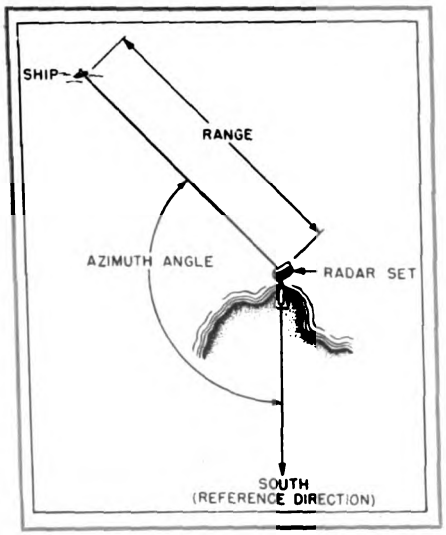


FIG. 2—Definition of range and azimuth

Some of the men responsible for the development and production of the AN/MPG-1 are listed in a footnote *.

Design Details

Essentially, the direction, or azimuth, of a target is specified by the direction of the beam when it illuminates the target. Azimuth

FIG. 3—PPI view of Pearl Harbor, 80,000-yard sweep with 10,000-yard electronic range markers

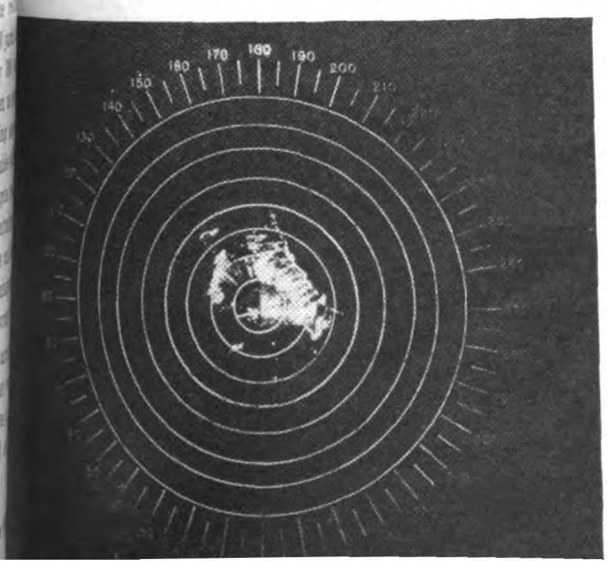
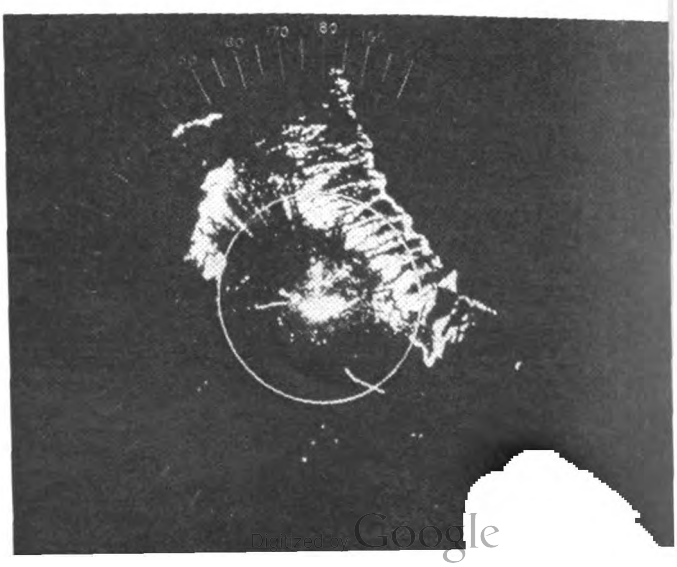


FIG. 4—PPI view of Pearl Harbor, 30,000-yard sweep with movable electronic range marker



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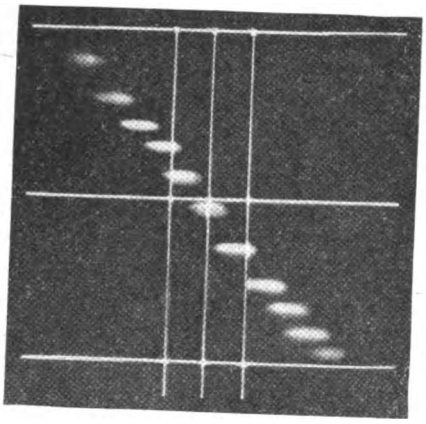

FIG. 5—B-scope presentation of eleven LCI's shown intercepted by the range marker in Fig. 4 at 12,900 yards and 329 degrees. Resolution makes it possible to distinguish ships separated by less than 300 yards of open water

and range are defined in Fig. 2.

Pulse transit time is measured by means of cathode-ray oscilloscopes. The oscilloscope range sweep is synchronized with a pulsed transmitter. At the moment an r-f pulse leaves the antenna, a linear deflecting voltage is applied to the oscilloscope electron beam. At the end of the desired time interval, the deflecting voltage suddenly falls to zero, allowing the electron beam to fly back to its original position where it remains until the transmitter is pulsed again, whereupon the cycle is repeated. Since the sweep trace is generated at a constant, known speed, any segment of this trace is a linear measure of time. After a pulse has been emitted and the sweep has begun, an echo may be received by the antenna. The echo signal is demodulated, amplified and applied to the indicator.

Surveillance

Surveillance data are viewed on a 7-inch conventional plan-position-indicator (PPI) on which two alternative maximum ranges, 80,000 and 30,000 yards, may be selected by the operator with the results shown in Fig. 3 and 4.

The PPI presentation is a polar map extending to the edge of the oscilloscope screen and displaying signals from all unshadowed reflecting objects at any horizontal distance from the antenna up to the maximum range of the set. The center of the map corresponds to the antenna location. Starting from the center of the screen in synchronism with the emitted pulse, the range sweep proceeds to the edge of the screen in the same relative direction as that taken by the pulse in free space. Rotation of the sweep is effected by means of a servo which causes the PPI deflection yoke to follow the movement of the antenna. To facilitate the taking of azimuth readings, a rotatable scale with an engraved line is provided over the scope face. When the engraved line is placed over a signal, the target azimuth is indicated on the scale. Target range is determined by the distance of the target signal from the center of the scope.

Eight fixed 10,000-yard electronic markers are provided on the 80,000-yard range. On the 30,000-yard range, instead of fixed markers a single electronic, movable range-marker is provided. This makes closer range estimates possible, for if the movable marker is cranked out to the target the approximate range will be indicated on a dial. The movable marker may be used in addition to target to be tracked on the scope. If the movable

TABLE I

CHARACTERISTIC	GEN
FREQUENCY	10,000
POWER OUTPUT	35 kw average
BEAM WIDTH (½-power points on transmitting beam)	0.6 deg plane
ANTENNA GAIN	19,000 vert.
TRANSMITTER	magne
RECEIVER	superh
Sensitivity	55 db
Local Oscillator	klystron
Intermediate Frequency	30 mc
Bandwidth	10 mc @ points
Maximum Gain	1,000,000
POWER CONSUMPTION (Complete equipment)	5 kva
	SEARCH
PULSE REPETITION FREQ.	1024 cps
PULSE WIDTH	1 μ sec
MINIMUM RANGE	200 yards
MAXIMUM RANGE	80,000 or 30,000 yards
RANGE ERROR	3 % of max. range
AZIMUTH ERROR	2 degrees

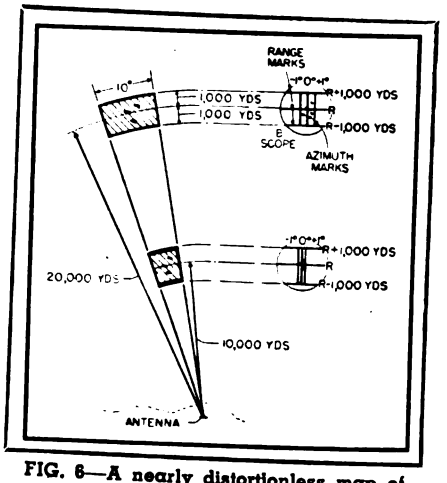

FIG. 6—A nearly distortionless map of the target area is obtained by means of azimuth expansion. Modified type-B presentation causes targets of like size and aspect to appear approximately the same on the oscilloscope screen regardless of their distance from the radar

marker is brought into coin with a target signal a antenna is positioned so t target is in the line of si target will appear near the of the tracking scope wh scope is switched on.

Tracking

An area 2,000 yards in by 10 deg in width is repre on the 7-inch tracking sc shown in Fig. 5. The cent this area corresponds to the section of the antenna line of with a circular arc, the radi which is equal to the range sented by the PPI movable marker. Type-B presenta employed (rectangular coord with range as ordinate and a as abscissa. The range starts near the bottom o screen, the azimuth sweep a left of center. Range and a electronically-generated marks intersect in the center screen. The tracking consists of displa signal until its t tered at the cro

* I. A. Getting, H. A. Straus, C. W. Miller, W. P. Manger, R. H. Caston, R. W. Illman, E. A. Holmes, A. E. Whitford, W. B. Coon, C. A. Wert, L. J. Rueger, E. Whitham, L. J. Chu, C. V. Robinson, H. Logemann, G. Hite, C. W. Sherwin, J. R. Niles, L. D. Smullin, R. V. Pound, F. T. Worrell, and D. B. Nichinson, all of the Radiation Laboratory, M.I.T.; M. Taylor, J. H. Taylor, P. De La Cova, R. J. Davis, A. R. Keskinen, J. B. Sherr, J. T. McNaney, S. J. Reisman, and A. E. Abel of the Bendix Radio Division; Lt. Col. J. J. Slattery, Capt. Vollum, Lt. D. M. Kerns, Lt. C. G. McMullen, W. B. Gould, W. B. Allison, R. A. Fletcher, F. W. Fisher and F. J. Kitty of the Signal Corps; Col. W. S. Bowen, Lt. Col. A. W. Clement, Maj. J. M. DuPare, and Sgt. L. A. White of the CAB; Lt. Col. M. B. Lampl, Army Ground Forces; Lt. Col. J. L. Dickey, USMC. This work was done under Contract Number OEMsr-262 und auspices of the Office of Scientific and Development, which onsibility for the accu contained herein.

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as the operators maintain
zet signal in this position,
e present-position data may
l from range and azimuth
nd transmitted electrically
telephone to a gun data
er over a standard base-end
ission system. Range and
n-aided tracking machines
ewing and tracking controls
vided to permit smooth and
te tracking.

nal or expanded Type-B
tation may be selected by
erators. In the normal dis-
he range scale factor (in the
l direction) is constant at
rds per inch, and the hori-
linear distance (on the tube
representing 10 deg in azi-
ls held constant regardless of

With the expanded Type-B
itation, however, the scale
in the horizontal direction
d constant at 400 yards per
resulting in an azimuth
itation which expands in
proportion to range. As a
of azimuth expansion, signals
targets of the same size and
appear to be approximately
ame size on the oscilloscope
n regardless of the target dis-
from the antenna. With this
of presentation, a nearly dis-
onless map of the target area
btained as shown in Fig. 6.
e the useful length of the tube
is approximately 5 inches, only
0 yards can be shown in the
izontal direction; and for ranges
xcess of 12,000 yards, the full
deg in azimuth can not be pre-
ted.

In addition to the fiducial mark-
electronically-generated azi-
th markers representing azi-
th + 1 deg and azimuth — 1
g, and range markers represent-
range + 1,000 yards and range
1,000 yards, are presented on
e tube face. A separate Type-B
cilloscope without expanded dis-
ay is located at a remote point
nd is used in spotting fall of shot.

It is impossible to operate simul-
taneously the PPI and B-scope
from synchronizing and video
pulses originated by the AN/MPG-1.
However, facilities are provided for
simultaneously operating the
B-scope and the PPI if synchron-
izing and video pulses and servo

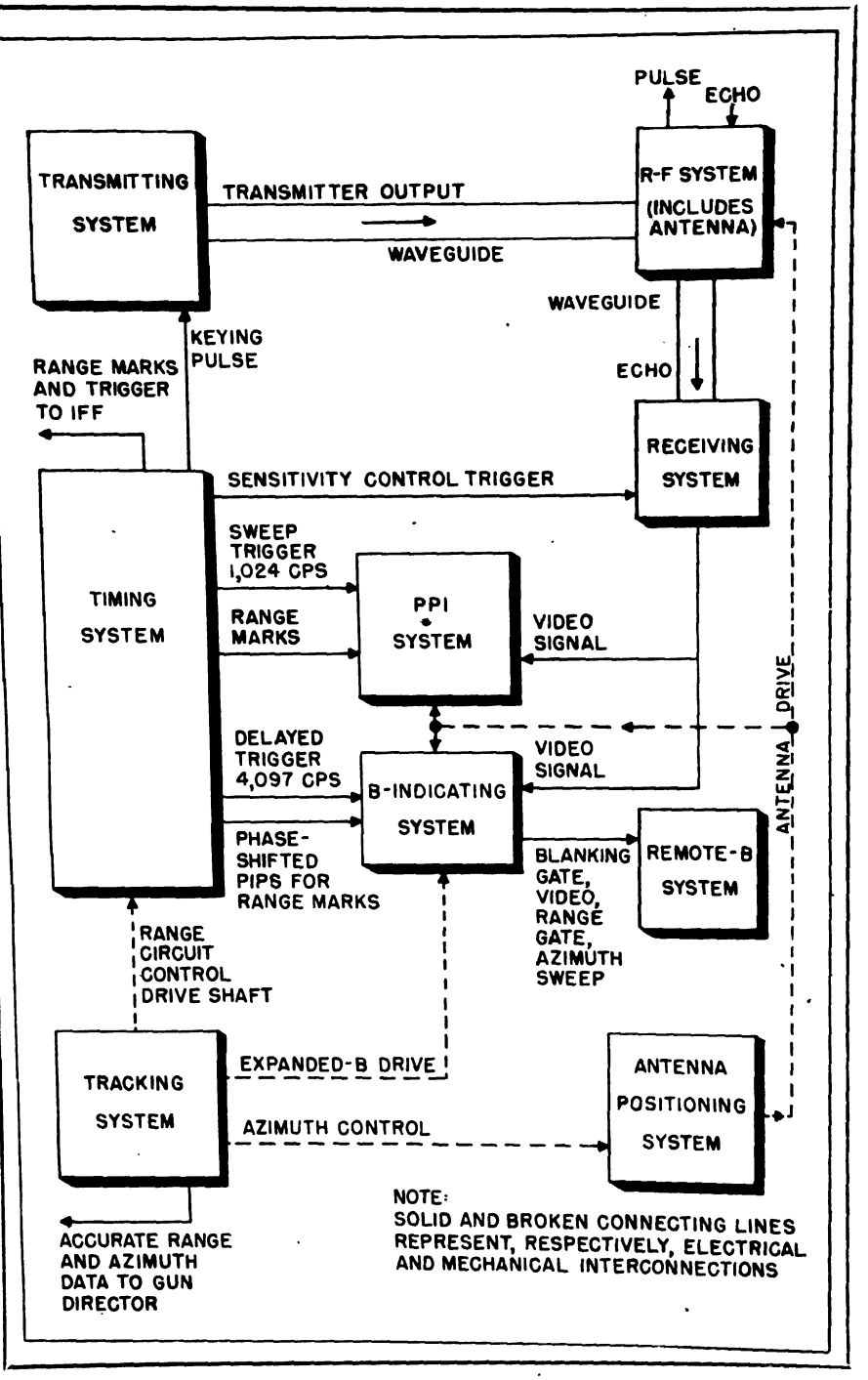

FIG. 7—Block diagram of the complete AN/MPG-1 radar, showing the nine major systems involved. Six of these are further broken down in the succeeding figures

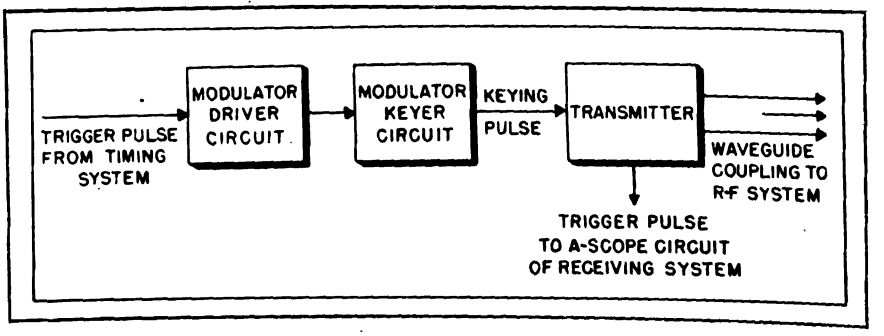

FIG. 8—The transmitting system, shown as a single block in Fig. 7

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data are fed to the set from a remotely-located, separate-surveillance set. This makes it possible for the operators to accomplish general sector surveillance on the PPI while tracking specific targets on the B-scope.

Component Systems

For purposes of explanation, the AN/MPG-1 is best divided into nine systems, shown in block diagram form in Fig. 7. Block diagrams of the main groups of circuits within each system follow.

The transmitting system shown in Fig. 8, triggered by a pulse from the timing system, generates pulses of r-f energy which are radiated into free space by the r-f system. A rectangular voltage pulse (of one microsecond width when the PPI is used and ½-microsecond width when the B-scope is used) is generated by the modulator driver circuit and applied to the modulator keyer circuit. A keying pulse (amplitude approximately −11 kv) is applied to the magnetron, which oscillates when the keying pulse is on. High-power, accurately timed, rectangular pulses of 3-centimeter energy are coupled to the r-f system waveguide.

The r-f system radiates pulses and feeds reflected energy to the receiving system. When properly adjusted, a coupling matching device shown in matches the transmitter impedance to the output. The duplexer, located in the receiver, contains TR and anti-TR switch tubes which permit use of the same antenna for transmission and reception. The waveguide feed arms, through which r-f energy is fed into the antenna, are provided in the rotating feed assembly. When the B-scope is used, one of the feed arms remains fixed at the center of the antenna throat, and energy is radiated in the direction of the antenna axis. When the B-scope is used, the feed assembly rotates at a speed of 4 rps, resulting in 16 cycles per second of the feed arms through the antenna throat. This rotation causes the emitted beam to sweep 16 times per second across a 360-deg sector centered on the antenna axis. The direction of the antenna beam is variable from zero degrees to 360 deg regardless of the type of presentation used. The antenna assembly forms the r-f energy into a narrow beam which is projected horizontally into space. Received energy is concentrated by the antenna assembly and fed to the receiver through the rotating joint.

The receiving system shown in Fig. 10 detects and amplifies the echo signals. A klystron local oscillator, a signal mixer and an afc mixer comprise a circuit which converts the received signal to the i-f signal of 30 megacycles. If the transmitter frequency drifts, the afc circuit changes the klystron repeller voltage, thus changing the local oscillator frequency by the amount needed to maintain the 30-megacycle i-f. The video output circuit detects and amplifies the i-f signal.

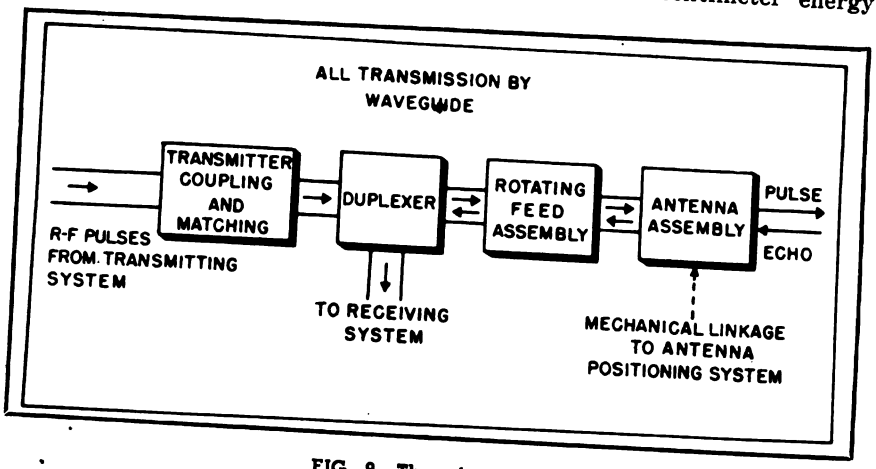

FIG. 9—The r-f system

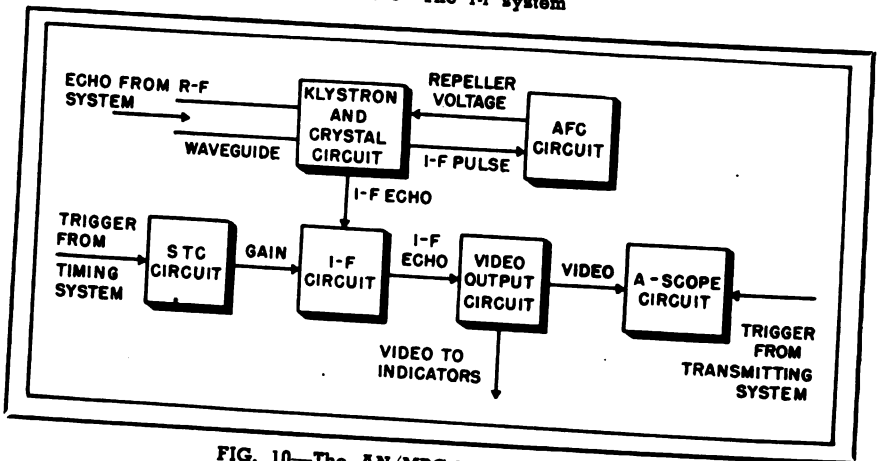

FIG. 10—The AN/MPG-1 receiving system

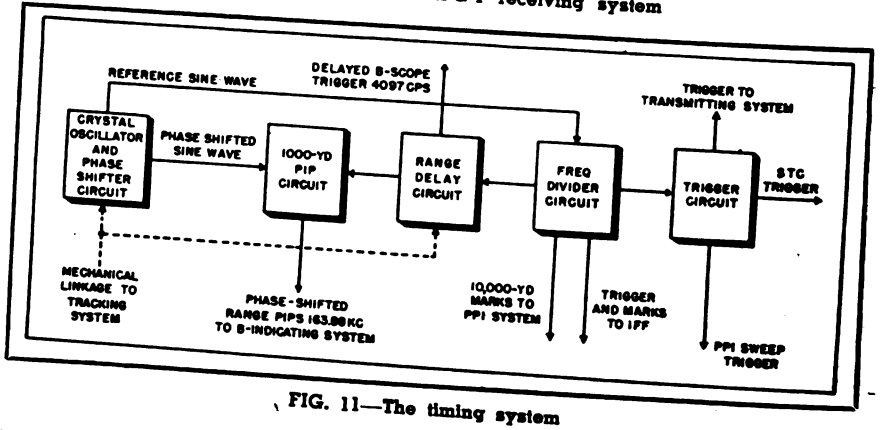

FIG. 11—The timing system

Pulse Timing

The timing system shown in Fig. 11 contains the synchronizing circuits for the entire radar set. Two outputs are obtained from the crystal oscillator and phase-shifter circuit; a 163.88-kc reference sine

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l a phase-shifted sinewave
me frequency. The phase
e between these two sine-
proportional to the range
dial setting. Pulses re-
at a rate of 163.88-kc are
from the phase-shifted
and fed to the B — indi-
system, where they are
into 1,000-yard range mark-
he time interval between
cessive 163.88-kc pulses is
the time required by a
ulse to make a round trip
rget 1,000 yards from the
. The 2,000-yard B-scope
ition, covering an area any-
from zero range to 28,000
is made possible by the
elay circuit which provides
B-scope range-sweep trig-
The delay is proportional to
ge-tracking output and is
ns whereby the 2,000-yard
area is moved in range.
ns of this circuit the posi-
the movable marker on the
ard PPI also is made
ent on the range tracking
Synchronizing triggers re-
for the radar set are derived
he reference sinewave.
PPI system shown in Fig.
used for general sector sur-
ce and selection of targets
tracked on the B-scope. A
onizing trigger is applied to
eep circuits either from the
system or a separate radar
Besides generating the sweep
e, the sweep circuit provides
ching gate for a remote range
er circuit which is operative
when the radar receives PPI
from a separate search set.
remote range marker circuit
uces 10,000-yard markers for
80,000 and 30,000-yard dis-
s. However, the local range
ker circuit provides 10,000-
markers for the long-range
and a movable marker for the
rt-range display. Synchronized
h the antenna through the servo
cuit, the PPI deflection yoke
ays takes a position such that
direction of the range sweep
licates the direction of the
itted pulse.
The B-indicating system shown
Fig. 13 provides a rectangular
ap of a 2,000-yard by 10 deg sec-
r centered anywhere within the
acking range of the set. The

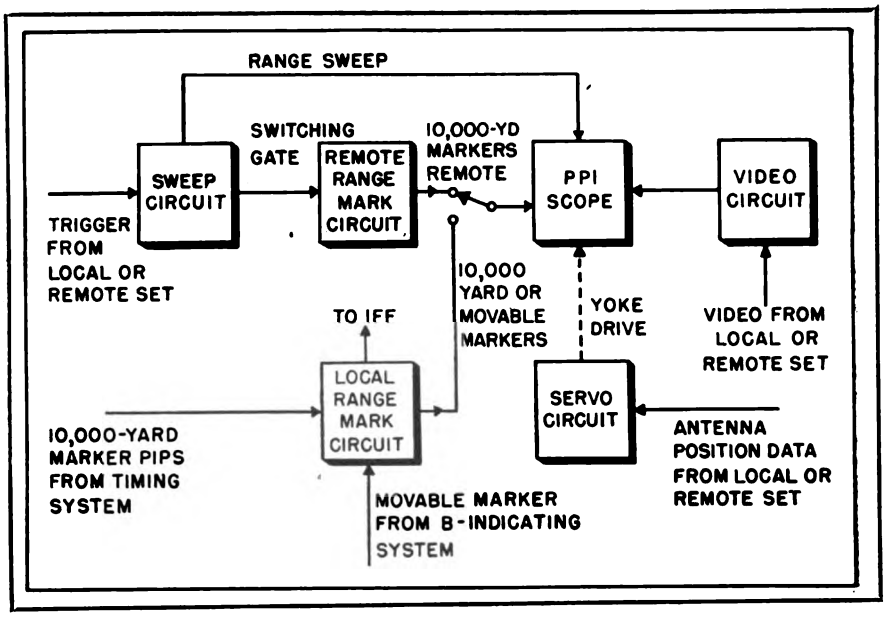

FIG. 12—The PPI system

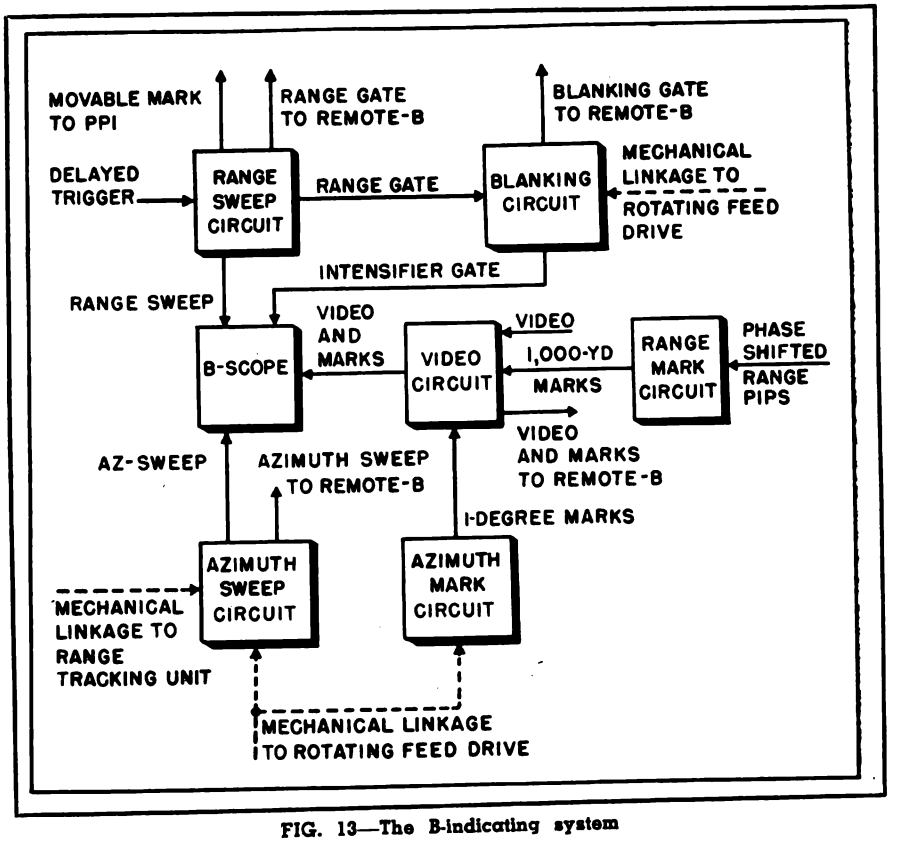

FIG. 13—The B-indicating system

azimuth sweep, markers and blanking gate circuits are mechanically coupled to the rotating feed drive. Received signals intensify the range-sweep traces. During the range-sweep fly-back interval, the B-scope is entirely blanked out. Expanded azimuth presentation is obtained through mechanical linkage to the range tracking unit.

By means of the antenna positioning system, the antenna is made to slew or scan on PPI or to slew or track on B-presentation. The tracking system provides aided or manual tracking in range and azimuth.

A special spotting mechanism is provided in the remote-B system that allows an operator to read range and azimuth deviations of the center of impact when he places curcors over the shell-splash signals. By this means the center of impact of succeeding rounds is made to fall directly on the target, and the military function of the set is fulfilled.

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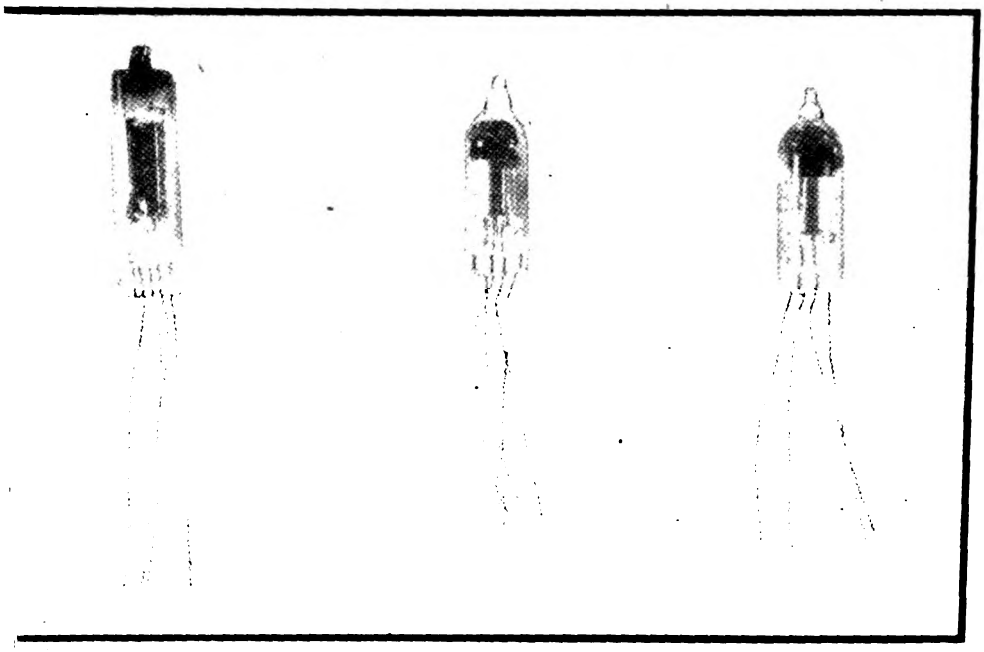
Generator-Powere

An electronic detonator. Wind-vane drives compact generator and arms projectile after safe interval of flight. Careful design of miniature r-f oscillator, feedback amplifier and thyratron circuits locates burst point at optimum position



Fuze tubes, shown approximately actual size. At the left is a triode, in the middle a pentode, and on the right a thyratron

THE GENERATOR-POWERED proximity fuze for airborne rockets, developed at the National Bureau of standards under the joint sponsorship of OSRD and Army Ordinance, is another example of the electronic detonating technique described in ELECTRONICS for November 1945. With the advent of the proximity fuze the saying "a miss is as good as a mile" is no longer true, because it has now been found that near misses can frequently be ten times as effective as direct hits.

Fuze Characteristics

The fuze to be described contains within it a complete radio transmitter and receiver, amplifier, electronic detonator, wind-driven generator, and safety devices, arranged as shown in the block diagram of Fig. 1. The rocket itself, together with an insulated ring mounted on the nose, serves as the transmitting and receiving antenna. An equivalent antenna and feed system are indicated.

When the rocket is fired its acceleration releases a safety latch which permits the power vane to rotate in the air stream. The vane turns the generator at about 40,000 rpm to supply filament, plate, and bias voltages. It also drives a gear train which connects the firing circuit after the fuze has traveled a predetermined distance, termed safe air travel. The fuze can be set for any desired safe air travel greater than a certain minimum. This arming delay insures that the fuze is always away from the launching plane before it becomes active.

Within a fraction of a second after the rocket has been fired the fuze circuit warms up and all transients die out. By the time the safe distance has been traveled, arming is completed, and the fuze is ready for operation.

Fuze Radiation Reactions

Assume that the fuze transmitter is in operation and that the rocket has come close enough to the target to receive appreciable reflected signal. The rocket sends out a continuous wave, part of which is reflected back to establish a small voltage across the antenna. This voltage is proportional to the antenna current but not necessarily in phase with it. The presence of the reflecting target thus has the effect of changing the antenna impedance by an amount Z such that $Z = e/I$, where I is the antenna current and e is the instantaneous voltage of the reflected radiation.

As the distance to the target decreases, two things happen. The size of e increases as the reflection becomes stronger and the phase between e and I changes by 180 degrees each time the target distance is reduced by a quarter wavelength.

The simple vector picture of Fig. 2 shows what goes on as the fuze approaches the target. Here Z_a represents the antenna input impedance (usually resistive as the antenna is tuned to resonance), Z_r is what there are no reflectors near by, and Z_t is the impedance due to the reflecting

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oximity Fuze

By
R. D. HUNTOON
d B. J. MILLER
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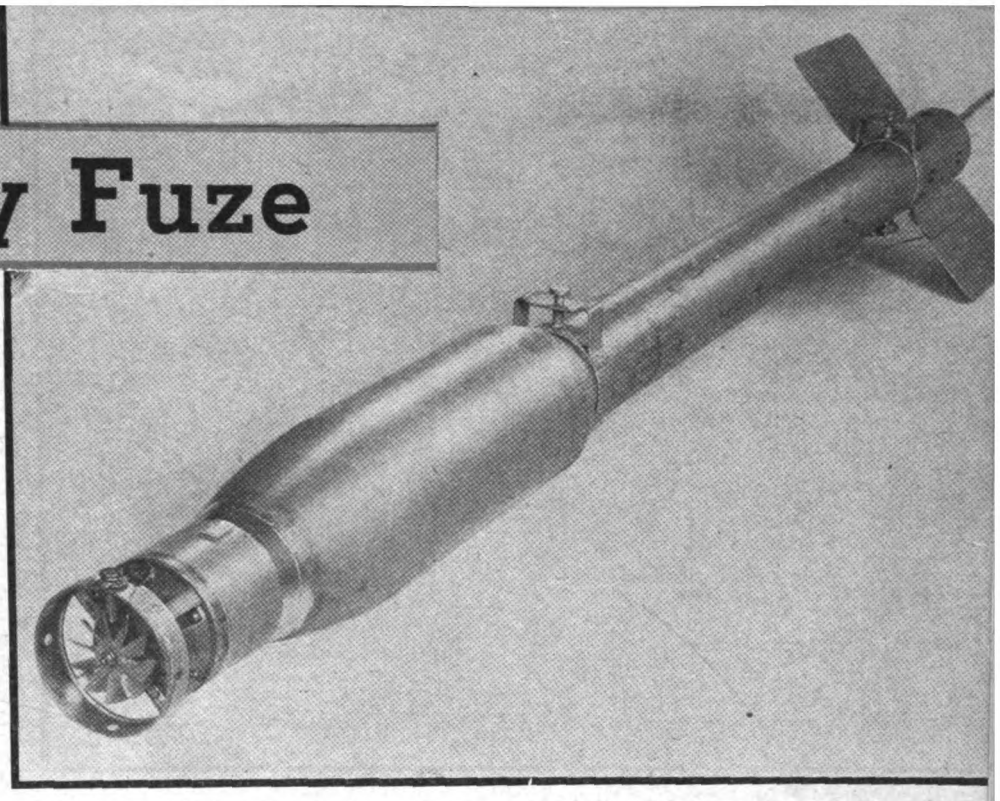
Washington, D. C.



Rocket armed with generator-powered electronic fuze

nted by Z. As the fuze ap- s the target the end of the r traces a spiral shown by ed curve. The total antenna nce thus varies periodic- m minimum (point A) to m (point B) going through e each time the path short- λ/2. If the velocity of the ward the target along the ning them is v, then

$$f = \frac{v}{\lambda/2} = \frac{2v}{\lambda} \qquad (1)$$

f is the rotational frequency This frequency has been the Doppler frequency because the same result is obtained if the difference between transmitted frequency and received frequency is calculated, taking into account the relative motion of fuze to target.

For small reflections the value of I (antenna current) is little affected by e (voltage due to reflection) and we can say that the size of Z is determined by e alone. The reflected voltage is determined by four factors: The reflecting power of the target, the distance to the target, the amount of radiation directed toward the target, and the

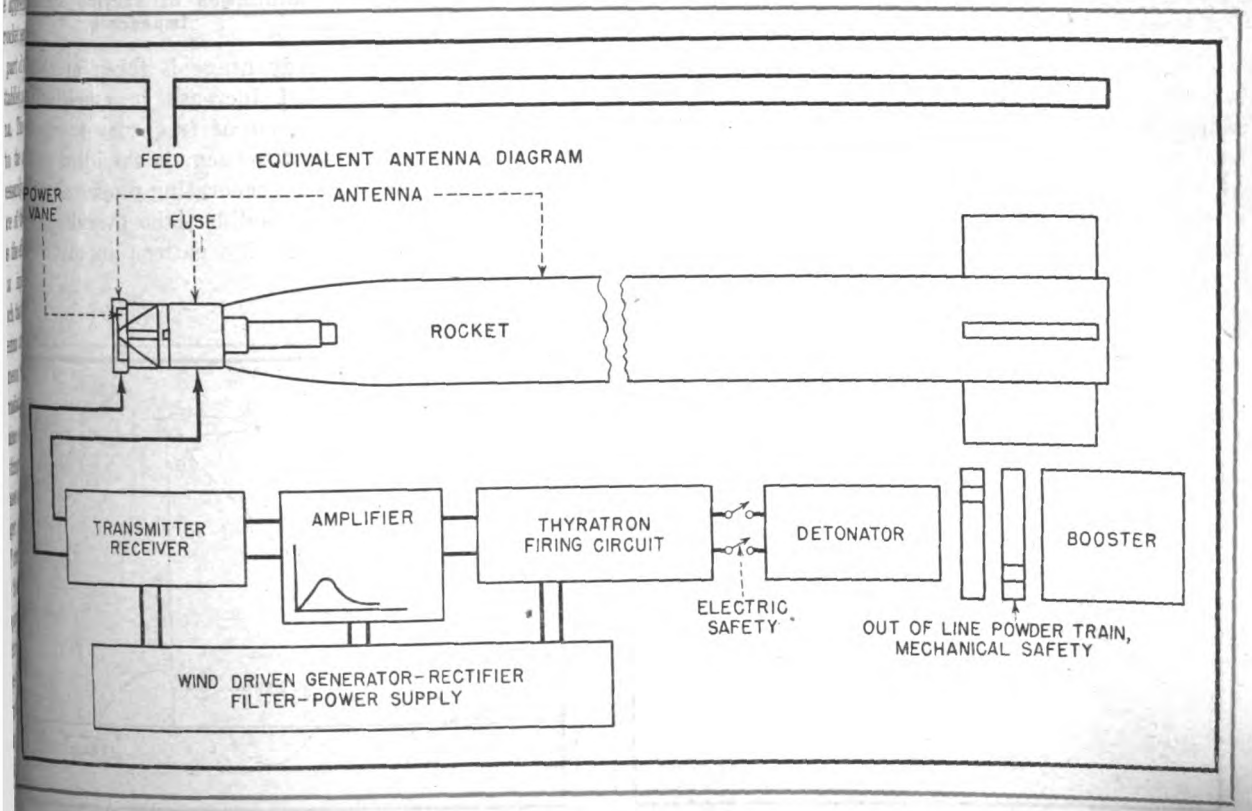


FIG. 1—Block diagram, showing at the top that the rocket constitutes a near-end-fed antenna. The electronic fuze fits into the nose of the rocket, and operates as shown to ignite a booster which fires the explosive charge

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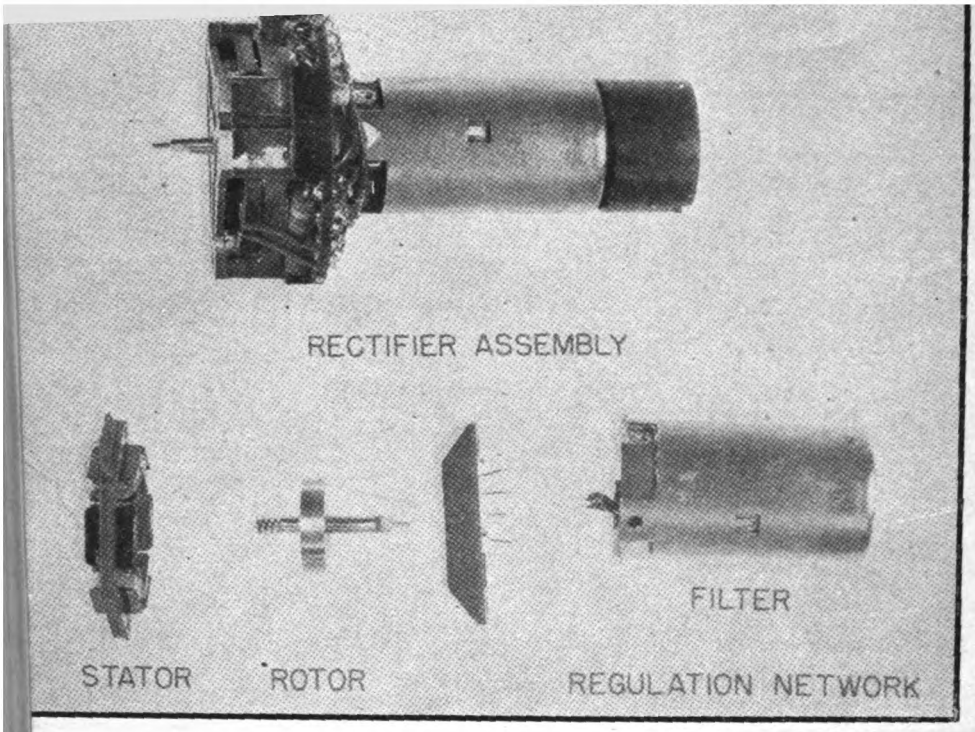

Separate parts of the wind-driven generator power supply for electronic fuse

receiving properties of the antenna for waves reflected back from the target. The first factor has been experimentally determined and found to be adequate. The second depends upon field strengths from antenna and target which decrease with increasing distance. The remaining two need further explanation.

Antenna Impedance Variation

The amount of radiation reaching the target is determined by the radiation pattern of the rocket antenna and the power radiated. Because an antenna has the same directional properties when used for receiving or transmitting, the radiation pattern is the same in each case. The square of the radiation pattern and the total radiated power thus determine the size of Z. In fact, it can be shown that the total radiated power is so related to Z_0 that Z is proportional to R_A, the resistance component of Z_0, no matter what the radiated power may be. Finally, then, the size of Z is determined by R_A and the radiating properties of the antenna, other things being equal.

The square of the radiation pattern is called the directivity pattern, the figure-eight loop around the rocket in Fig. 3 being the envelope of a typical pattern. The actual directivity envelope in space is a figure of revolution about the axis of the rocket, roughly a doughnut-shaped figure. This envelope shows how well the fuze sees targets in various directions. Since the figure-eight envelope the fuze sees mainly to the sides and not at all straight ahead, thus good shots are not detonated before they reach the target.

Figure 3 represents the situation when a rocket passes an airplane. The dotted curve plotted along the rocket trajectory and marked M-wave represents the idealized resistance component of Z at successive points.

Now $v = V_0 \sin\theta$, and $(2v\sin\theta)/\lambda$ if V_0 is the speed of the rocket in a coordinate system attached to the target. As the fuze approaches the target the size of Z grows rapidly because the distance shortens and the directivity improves. The rotation of Z [illegible] down from the value $f = 2v$ at large distances to the value f at the instant $\theta = 0$.

This analysis indicates that the characteristics of the reflected impedance are rapidly growing in magnitude and rapidly falling frequency as the fuze approaches, and the reverse as it passes beyond the target.

Utilization of Varying Antenna Impedance

Advantage is taken of the combined increase in amplitude and decrease of frequency to cause the burst to occur in the ideal position. By incorporating proper shaping in the amplifier, the overall effective directivity pattern is made more

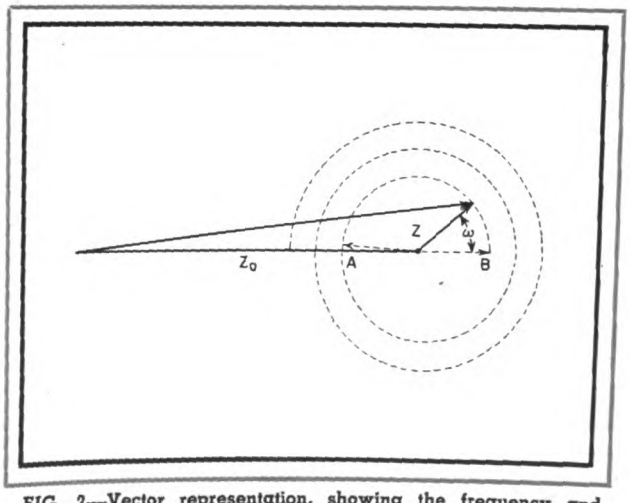

FIG. 2—Vector representation, showing the frequency and [illegible]amplitude changes of antenna impedance

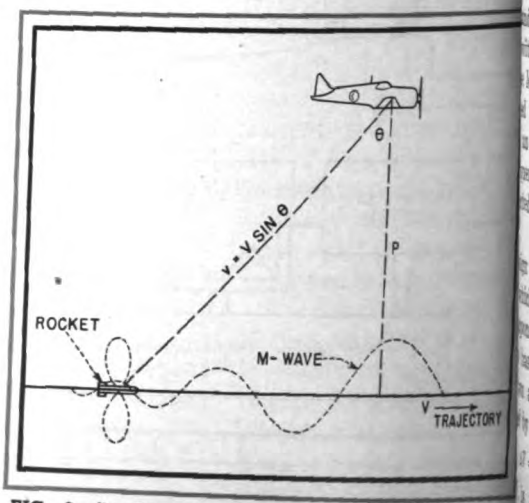

FIG. 3—As the rocket approaches its target the radiation resistance varies

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than that due to radiation
igure 4 indicates the effect.
bining amplifier character-
d radiation characteristics
ssible to draw an effective
ity pattern which is a locus
points.
tain proper operation, it has
nd by experience that the
st burst when Z is a very
raction of R_A. The fact that
e operates on a percentage
in antenna impedance im-
at fuzes will function at a
distance from a reflector
regard to the power radi-
Although fuzes have been
hich work over a range of
evels as large as 5000 to 1,
wer is desirable because it
s strong signals, strong re-
and reliable operation.

ivity of Transmitter-Receiver

n the effect of the reflecting
is expressed as a change of
a impedance as outlined
it is easy to see how a single
can transmit continuous
receive the reflected signal,
lect the low-frequency com-

oscillator shown in the func-
block diagram of Fig. 5 sees
riable load which changes
ically from increased resis-
to increased reactance to de-
d reactance to decreased
ance. If the plate circuit of
cillator is tightly coupled to
ntenna, the small reactance
es will alter the frequency
illation with but little effect
scillator performance. The
es in resistance, on the other
alter the power drain on the
tor, and certain parameters
iated with the oscillation will
w these load variations. Thus
detected output voltage will
in it an alternating compon-
of frequency $f = 2v/\lambda$ which
be selected and used as a work-
signal.
he design of an effective r-f
llator which will give a strong,
le response to small load
nges is based upon a figure of
it known as the sensitivity S
defined by the relation

$$\Delta V = S\Delta R_A/R_A$$

ere ΔV is the change in de-
ted output voltage, ΔR_A is the

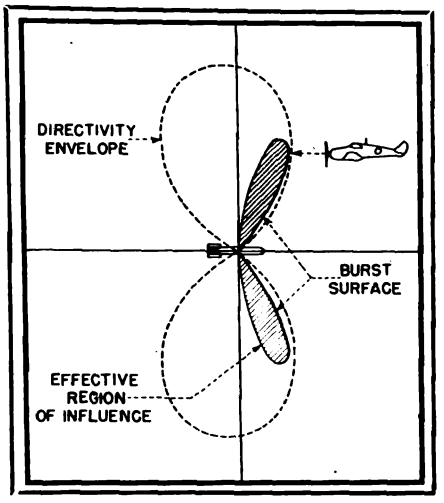


FIG. 4—By means of wave-shaping circuits in the fuze amplifier the effective influence region is modified as compared with the radiation pattern

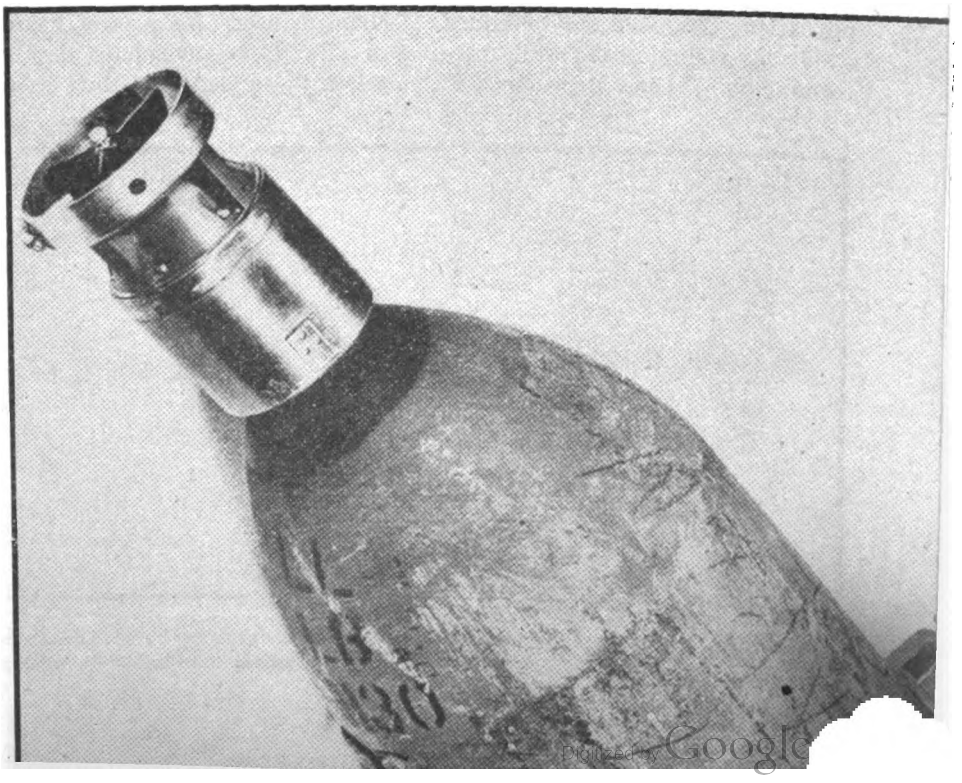
resistance component of Z, and R_A is the resistance component of Z_0. Usually R_A is equal to Z_0 because the antenna circuit is tuned to resonance.

To predict the performance of a transmitter circuit a typical curve of V vs log R_A is plotted as in Fig. 6 for various values of R_A. The slope of this load curve gives the values of S for small values of $\Delta R_A/R_A$ corresponding to the radiation resistance R_A of any antenna that may be connected to the r-f circuit. The curve labeled S shows the sensitivity of the circuit at each value of R_A. It is important to note that S is relatively independent of R_A over a large range. This independence of S with load changes means that the circuit is usable on a variety of antennas. The particular oscillator selected combines high efficiency with a large stable S which is relatively independent of tube parameters and load resistance.

One of the most important problems to be overcome in fuze production was the design and development of a triode oscillator tube that would give good power output with relatively small plate supply voltage, have a good S value, and operate in a simple circuit so stable microphonically that the small available signal would not be masked by vibration of the projectile during its flight at supersonic velocities. The resulting tube is similar in appearance to a standard hearing-aid type but more rugged in construction. In rocket applications, tubes are subject to accelerations of only 30 to 150 g, but the tubes developed to withstand the vibrations encountered were found sufficiently rugged for use at accelerations as high as 10,000 g.

Owing to limited space, highest efficiency of the oscillator is necessary to insure strong reflected signals and reliable operation. For small reflections, Δ_r is proportional to ΔR_A and the M-wave (Fig. 3) can represent the approximate wave

Bomb armed with electronic proximity fuze. It detonates above the ground, spraying fragments into dugouts and gun emplacements more effectively than contact-detonated bombs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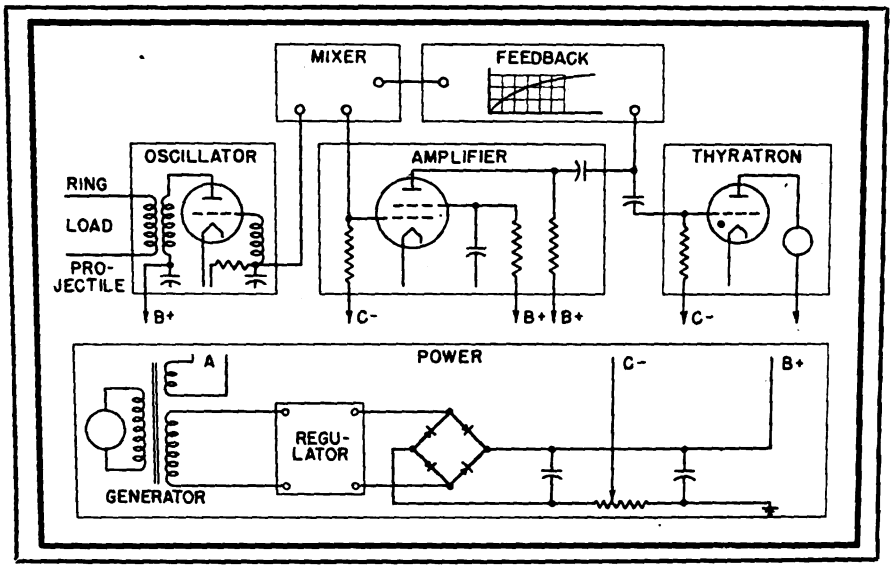


FIG. 5—Break-down of typical radio fuze circuit

form into the amplifier, as well as the variation of antenna impedance.

Signal Amplifier

Because the signal from the r-f section is too small to actuate a firing device directly, it is necessary to amplifiy it until it can reliably operate a thyratron.

The amplifier also performs important secondary functions. The shape of its gain characteristic assists the directivity pattern in properly locating the point of burst, and much of the tube microphonic noise, and filament a-c hum are suppressed by proper design. It is possible to make a single tube perform all these functions although there are limits to the amplification that can be obtained stably by a single tube while performing all of them. Dependence is placed upon the high stable *S* of the oscillator and, for discrimination, upon feedback.

The amplifier (Fig. 5) is conventional in every respect, using a small tube especially designed for high gain. The feedback network gives regenerative feedback at the desired frequency plus high degenerative feedback at high frequencies and no feedback at low frequencies. The consequent sharp cut-off at noise frequency suppresses tube microphonics and hum.

Hum Problem

Currently available heater-type tubes warm up too slowly and are more microphonic than the filamentary type, so directly heated filaments are used. Because of generator design requirements, a-c is used on these filaments, thus creating a very serious hum

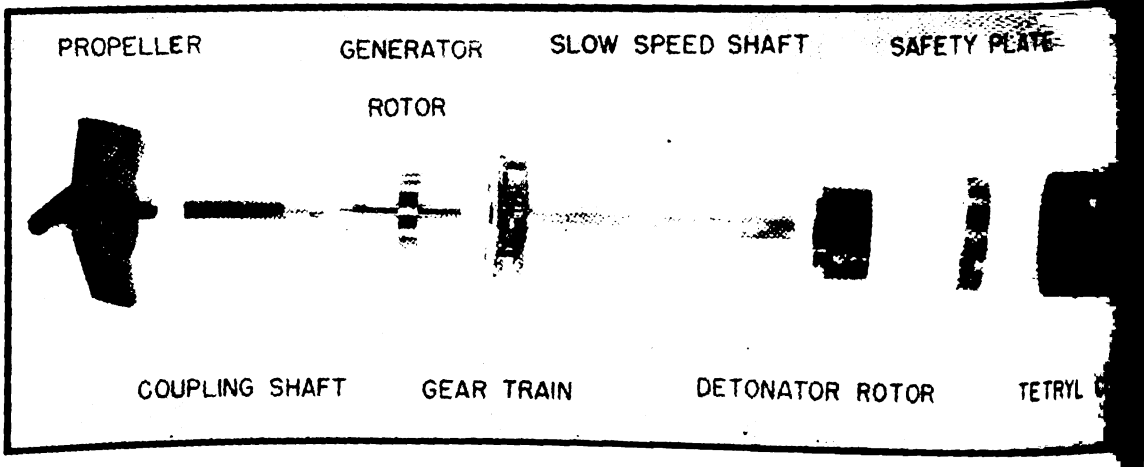
The r-f section puts o
filament frequency with
tude many times larger
working signal which m
arated from it. If disc
networks are connected
put of the amplifier, it is
by the larger hum input
gain at signal frequency
reduced. Discrimination
put is possible but requir
erable circuit complexity.

So the amplifier is made
degenerative at hum fr
Thus, to suppress one vo
input, the amplifier only
erate slightly more than
output which is fed ba
phase to the input where
the hum from the r-f sec
net result is amplification
frequency very much gre
at hum frequency. The ou
nal-to-hum ratio is there
high enough to provide
margin of safety for prope
tion.

Every stage in the fuse
must operate at its optimu
efficiency. Although there
than sufficient power to d
generator, the limitations
prohibit a large generator.
number of separate stages t
be added is restricted.

Burst Location

The frequency of maxim
is selected by trial to give
burst location. As the f
proaches the target the fr
first received is too high
gain too small to actuate



Safety devices, operated in sequence, by wind-driven propeller shaft, arm fuze after a rocket is fired from under the wing of an airplane

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When it gets closer the
f the detector increases be-
e target is in a better posi-
e seen, and the frequency
where the gain is higher.
bination of these factors
the region of influence
the fuze more sharply de-
an the directivity envelope
ould indicate.

the output from the ampli-
eeds its critical value, the
actions and bursts the pro-
The actual explosion is ini-
y the discharge of the final
r of the filter through the
n and a detonator similar
sting cap. Thyratron bias
tor in determining the loca-
the burst.

detonator ignites a powder
hich in turn sets off the
to explode the main charge.
one millisecond elapses be-
the firing of the thyratron
e moment fragments start
the projectile, during which
e missile has moved very lit-
spite its small size, the thy-
is capable of repeatedly pass-
rge peak currents, without
ing its characteristics, allow-
oper factory tests.

Power Supply

e use of a battery, even of the
e type, seriously limits the
y of a rocket fuze. It must
y proper voltage after being
ed aloft to very low temper-
s (−40 C) and at present
is no acceptable battery which
meet both the severe temper-
e and space limitations. There
o spin and little acceleration in
ket to actuate a reserve bat-

ecause more power can be ob-
ed for a given volume by using
enerator than by any battery
available, design of a small
d-driven generator was under-
n.

he power system consists of gen-
or, regulator, rectifier and
er. The generator rotor is a
ll, permanent magnet and the
tor is a series of coils. Separate
ment and plate windings are
vided. Raw a-c is used for all
ments. The plate voltage is rec-
ied by a small selenium bridge
ctifier and filtered by an R-C cir-
cuit. Bias voltage is obtained by the plate current drop in the filter and is adjustable to afford some compensation for production variation from generator to generator.

The large internal impedance of the generator serves two functions; it materially assists in the filtering action and it makes voltage regulation easily attainable. By adding a regulating circuit to the generator the variation of voltage with speed can be reduced almost to zero over a wide range of speed.

Figure 7 shows a typical speed-regulation curve. Achieving such a curve requires a careful selection of combined generator-regulator-filter parameters such that the best compromise on all values is obtained to reduce variations in mass production to a minimum.

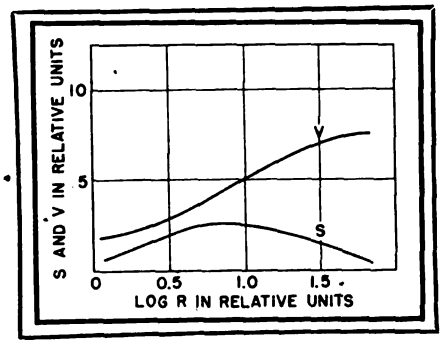

FIG. 6—Sensitivity varies so little that the fuze can be used in a variety of projectiles, i.e., with different antennas

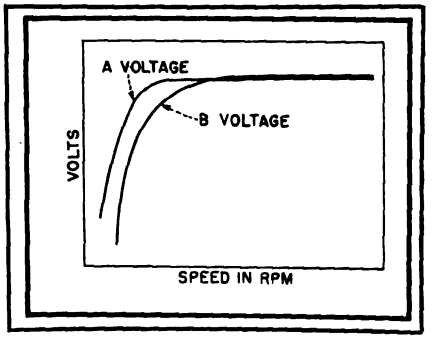

FIG. 7—Good regulation with varying generator speed is obtained by choice of generator and filter impedance

An important secondary feature of the generator is its contribution to fuze safety. There is no power to actuate the mechanism unless it is flying through the air. Likewise, fuzes are inert once the generator stops spinning.

An incidental advantage of generator operation arises from the gear-reduction arming that can be readily incorporated. Long air travel-to-arming-time ratio is feasible if desired as it is in certain applications such as ground-to-ground firing of rockets or howitzers.

Safety Devices

In addition to driving the generator, the wind vane drives a gear reduction system to actuate the safety devices. By proper selection of the gear ratio any desired safe interval can be incorporated into the fuze. The slip of the vane is remarkably constant and the system can be used to adjust for any desired fixed air travel to the arming point.

As the propeller turns, a small, Bakelite rotor carrying the electric detonator slowly rotates. When it has turned so that it is in line with the powder train, the final connections to the circuit are completed and the rotor is disengaged from the shaft. The fuze is then armed and ready for action. Until then the detonator is neither in the circuit nor in line with the powder train, thus giving dual safety.

Production

The fuze must be small. Small tubes and small generators have been mentioned. Without other small components the device would still be impossibly large. The electronic industry has successfully supplied small resistors, capacitors, coils and rectifier cells; all strong, temperature resistant and vibration free.

The production of fuzes required previously unheard of discipline at the assembly lines. One loose contact vibrating in response to noise can undo the work of the best components. Manufacturers responded magnificently in establishing mass-production facilities despite the stringent inspections and heart-breaking rejections which were necessary to maintain adequate quality in the final product.

This paper is based upon the work of the Fuze Development Staff, Ordnance Development Division, National Bureau of Standards, under the direction of Harry Diamond. The program was conducted under the sponsorship of Army Ordnance Department and Division 4, NDRC.

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The SCR-584 Radar

Details of the r-f system and receiver of the outstanding anti-aircraft gunfire-con radar, including hitherto unpublished information on microwave plumbing, rota joints, crystal mixers, t/r tubes, and gated i-f amplifiers. Operating principles and cifications were given last month

The radio-frequency pulses generated in the cavity magnetron of the SCR-584, as described in the first installment (ELECTRONICS, November, 1945, page 104), are conveyed to the radiator by a system of microwave plumbing and components known as the r-f system. The echo pulses rec from the target are conveyed the radiator to the receiver thr the same system. In this ar

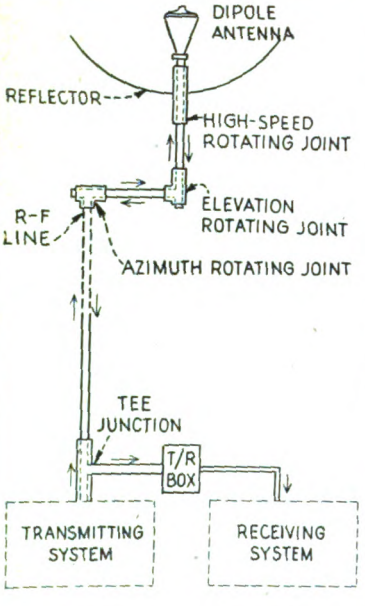

FIG. 1—Block diagram of the r-f system, by which the transmitted pulses and echoes are conveyed to and from the radiator

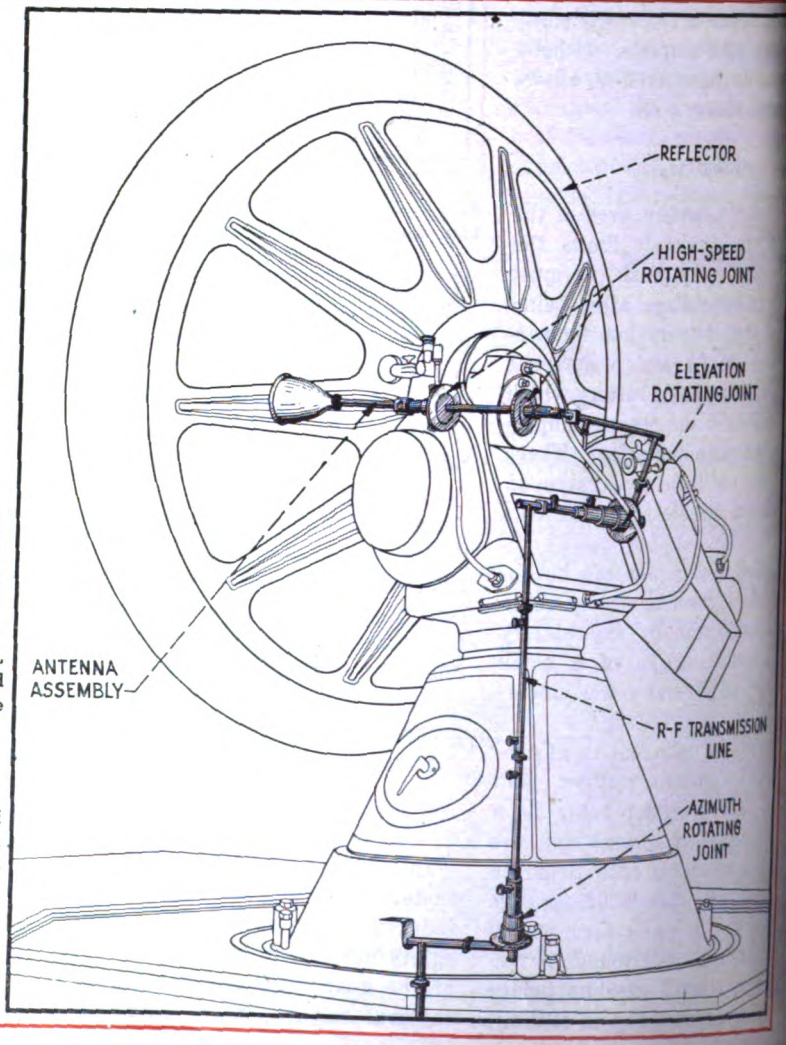

FIG. 2—Perspective view of the r-f transmission line and rotating joints, from magnetron output to dipole radiator

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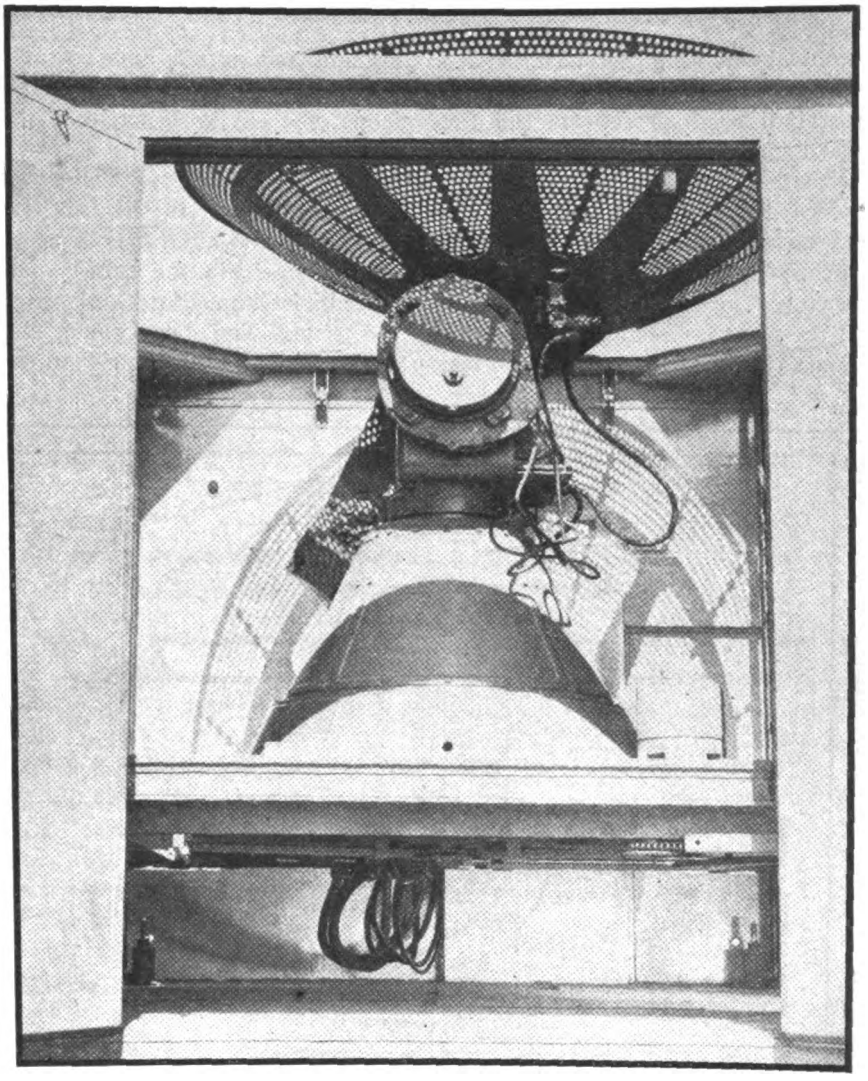

of antenna and platform of radar
584, partly raised out of the trailer.
operation, the platform is up flush
with the roof of the trailer

tails of the r-f system and
r are described.

Functions of the R-F System

essential components of the
tem are shown in the block
m in Fig. 1 and in perspec-
Fig. 2. As the r-f pulse
the transmission system it
ters a T-junction, which
three coaxial lines. One
leads to the radiator.
ite the signal passes through
rotating joints. These joints
t the radiator to move in azi-
and elevation for helical scan-
and permit the dipole radia-
be spun about the axis of the
oloid, for conical scanning.
remaining branch of the
ction leads to the receiver.
his branch the transmitted
l encounters the t/r (trans-
ceive) box, a low-pressure
discharge tube which breaks
and prevents passage of the
g transmitted signal to the
ver. At the conclusion of the
smitted pulse, the t/r gap
nizes, and the echo signals
eafter received are passed to
receiver. Coincidentally, the
edance of the cavity magnetron
ges, so that the echoes are re-
ed from the transmission sys-
with but minor loss due to
orption.

he transmission lines them-
es are of the coaxial variety,
h the inner conductor supported
ntervals by quarter-wave stubs.
diameter of the inner con-
tor is increased at the stub, and
one quarter wave on either side,
ncrease the frequency band over
ich the stub support introduces
ligible loss. A typical stub sup-
t and a joint in the line are
wn in Fig. 3. The rotating
nts are shown schematically in
. 4. Each joint consists of quarter-wave overlaps between outer and inner conductors, within each of which is a small gap. The gap permits passage of the r-f energy, by capacitive action, while allowing free rotation of the joint about the axis of the line. Each joint is covered with a gas-tight seal which permits the lines to be filled with dry air under five pounds pressure.

Dipole Radiator

The dipole radiator is shown in Fig. 5. A plastic housing surrounds the assembly to contain the air under pressure. The coaxial line is surrounded, at the left, by a quarter-wave collar which converts the single-ended feed of the line to the push-pull feed required to excite the dipole. The inner conductor is built up to large diameter, as shown, thereby changing the impedance of the line so that it matches the impedance of the dipole. The dipole itself consists of two rounded projections, one soldered directly to the outer conductor, the other connected to the inner conductor and projecting through a hole in the outer conductor. The two segments of the dipole are of different lengths so the radiation from it is slightly assymetrical with respect to the axis line. As a result the axis of the beam is displaced from the axis of the paraboloid and as the dipole spins the beam traces out a cone

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(conical scanning, see part I).

At the right of the assembly is a metal disk which reflects the forward radiation from the dipole, returning it to the reflector. This forward radiation would otherwise be largely wasted since it would spread outside the limits of the beam. The coaxial line is shorted at the righthand end, at such a distance from the dipole that the signal reflected from the short appears in proper phase at the dipole to reinforce the radiated signal.

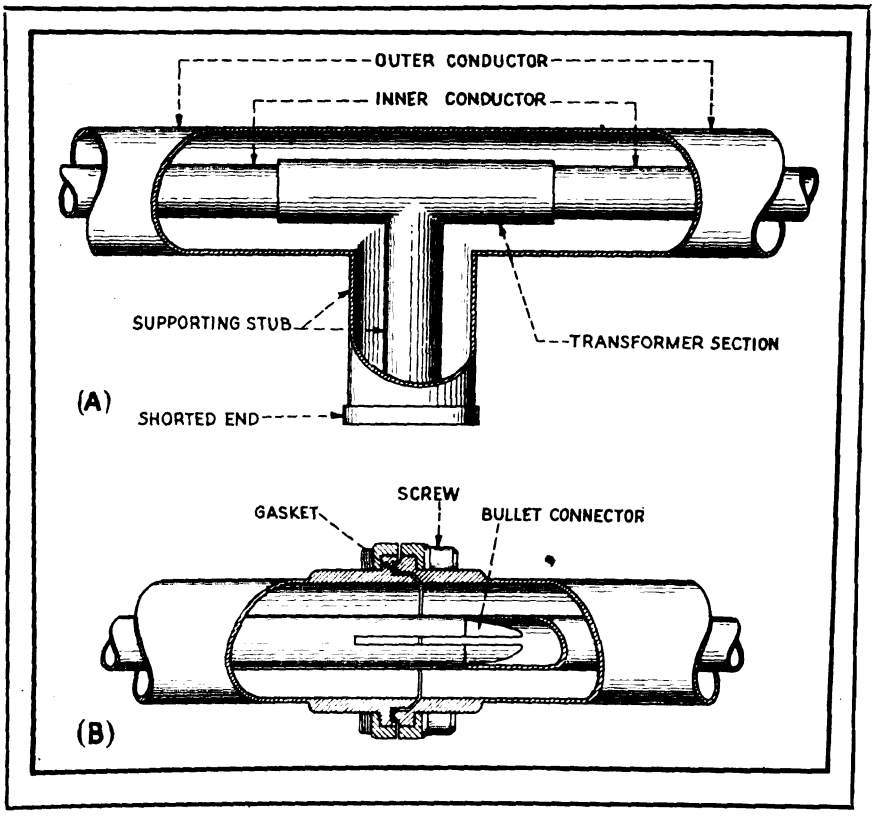

FIG. 3—Coaxial transmission line fittings: (A) broadband quarter-wave stub support; (B) in-line joint

Transmit-Receive Switch

The t/r box (Fig. 1) is a device which permits the use of the same radiator for transmission and reception. Its essential element is the t/r tube (type 713A) shown in Fig. 6. This tube comprises two conical electrodes supported on metal flanges which extend through the glass envelope and become part of a resonant cavity (Fig. 6A). The cavity is tuned by tuning plugs to resonate at the carrier frequency. Consequently when the transmitted signal appears at the cavity input (through a coupling loop), the cavity is excited, and a high potential appears across the conical electrodes. Sufficient free ions are present in the tube (supplied by an auxiliary keep-alive electrode within the tube) to permit almost immediate ionization of the gap. The breakdown short-circuits the cavity and detunes it so that the magnetic field within it collapses at once, and the signal is prevented from leaving the cavity via the output coupling loop. The tube is filled to a pressure of about 1 mm of mercury of water vapor, which ionizes in a few hundredths of a microsecond.

At the conclusion of the transmitted pulse, the gap deionizes (the recovery time is about 1 microsecond), and the cavity regains its tuned condition. Thereafter, when echo signals are received, they excite the cavity (but to such a low power level that the gap does not break down) and they are coupled through the cavity directly to the receiver input circuit of rece

In the discharge conditi t/r box introduces an atte to the transmitted signal o 60 decibels, which reduc power from 300 kw to well 100 milliwatts. This level i enough to be harmless to ceiver but sufficient to exc receiver so the transmitted is visible on the type J range The power consumed in ma ing the gas discharge is ne compared to the 300-kw level transmitted pulse.

The Receiving System

A block diagram of the re system is shown in Fig. 7. echo signal is passed by the t directly to the crystal mixer, it is combined with a loca lator signal 30 mc higher i quency. The 30-mc interm frequency is then amplified i i-f stages (preamplifier) whi mounted directly adjacent t crystal mixer. The remainin stages are located (for conveni at some distance, in the re proper. After the fifth i-f the i-f channel breaks up int branches, one (the range cha feeding the indicators, the (servo channel) feeding the tracking circuits.

The circuits of particular i est in the receiving system those which convert the c frequency to the intermediate quency. Care must be take these circuits to maintain the level as close as possible to inescapable noise level introd at the antenna itself.

Crystal Mixer

The three most serious sour of additional noise, in order importance, are the crystal mix the i-f amplifier and the local os lator. The first two i-f stages located as close as possible to mixer stage to avoid losses at lo level in the connecting cable. attention to such details it has be possible to keep the noise in t receiver output to within 15 db the theoretical level present in t antenna circuit.

The multi-grid converter tube

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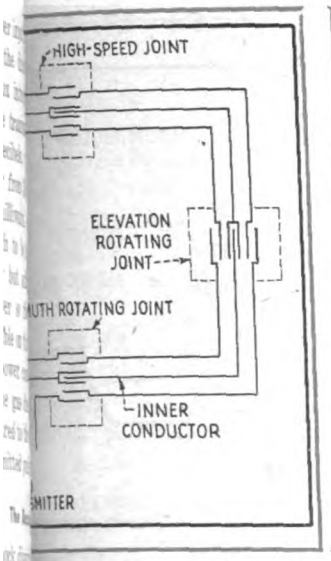


-Rotating joints. The r-f signal mitted past the air gaps by capacitive action

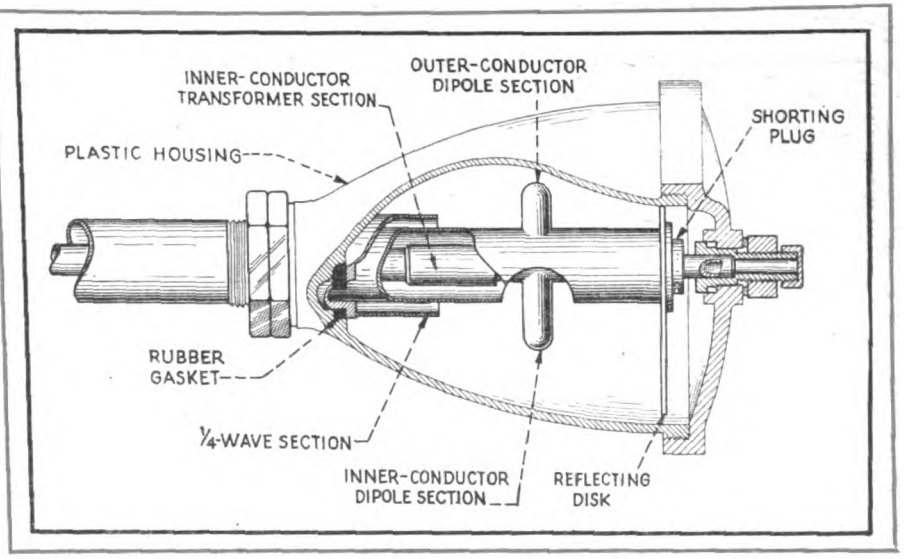
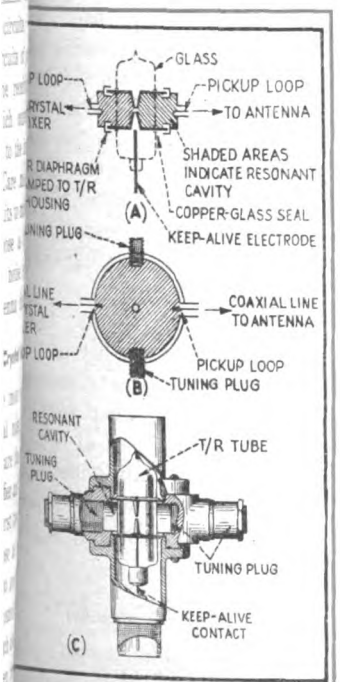


FIG. 5—Dipole radiator, transformer sections and reflector plate. A slight difference in the length of the dipole elements produces off-axis radiation for conical scanning

superheterodynes at lower ies are not suitable at ve frequencies because of se introduced by random tion effects at the grid The diode is accordingly for microwave applications. st efficient form of diode thus far uncovered is the crystal. A slab of silicon, y heat treated and etched, tungsten catwhisker bear-



G. 6—T/r tube and resonant cavity.) Schematic view, side; (B) schematic view, top; (C) cut-away view

ing upon it, is mounted in a small cartridge and the whole assembly filled with a plastic compound.

The cartridge is mounted in a housing, known as the mixer, shown in Fig. 8. The coupling loop at the lower left abstracts the received signal from the t/r box and passes it to the crystal. The local oscillator input, at a level of 25 to 50 milliwatts, is fed through the arm at the upper right, through a right-angle bend to a coaxial member whose inner conductor terminates near the crystal in a flat coupling plate. The level of the local oscillator signal is controlled by the screw adjustment until the rectified direct current passing through the crystal is about 0.6 ma.

The i-f output is developed between the base of the crystal cartridge and ground, and is fed out through the arm at the lower right to a flexible coaxial cable which connects with the i-f preamplifier. In the output line is placed a small metal cup, insulated from the outer conductor by a thin section of mica insulation. The capacitance thus formed acts as a short-circuit at carrier frequencies and thus prevents absorption of the r-f signal in the i-f amplifier. The capacitive reactance is, however, 100 times as great at 30 mc as at 3,000 mc, so the bypass has relatively little effect on the i-f components. The mixer has no tuned elements and is constructed to operate without adjustment over the range from 2,700 to 2,900 mc.

Local Oscillator

The generation of c-w power at 3,000 mc, even in the small amount

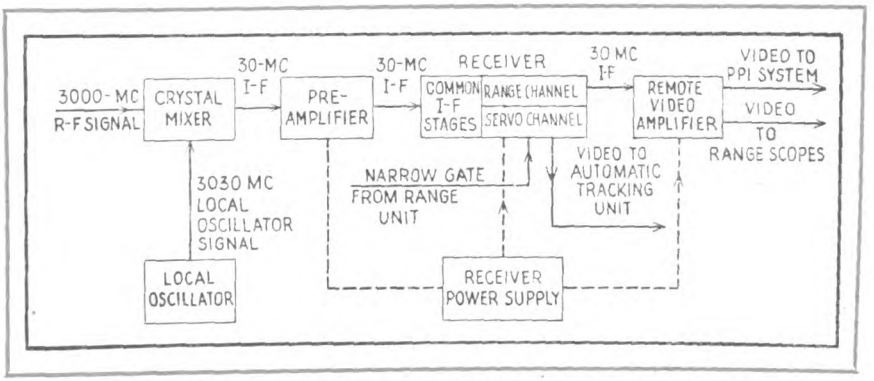


FIG. 7—Block diagram of receiving system. This system converts the r-f echo pulses at 3,000 mc to video pulses which actuate the c-r indicators and auto-tracking circuits

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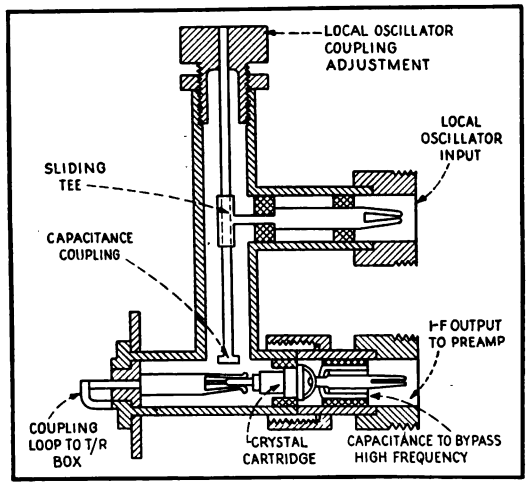

FIG. 8—Vertical cross-section of the r-f mixer. The local oscillator is loosely coupled to the silicon cartridge

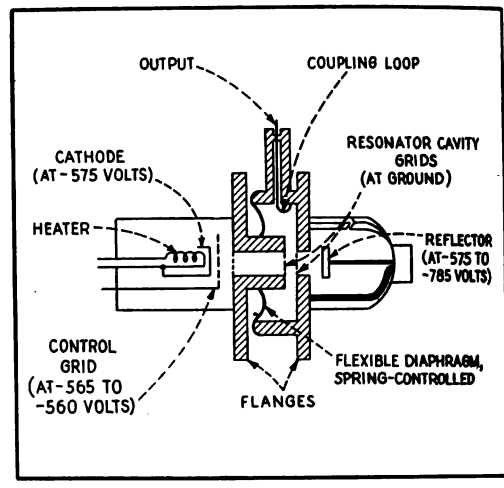

FIG. 9—Cross-section of the reflex klystron, used as a local oscillator in the receiver

required for local oscillator service, is a difficult task because of transit time limitations. To avoid these difficulties, the local oscillator tube employs the klystron principle to separate the effects of transit time from the oscillating circuit. The particular form of klystron used is a single-cavity type known as the reflex klystron, illustrated in Fig. 9. It operates as follows: Electrons from the cathode are formed in a beam and accelerated at about 575 volts. The beam passes within the center post of a cavity resonator and thence through two grids which are part of the cavity walls. The initial passage of the electrons causes a weak oscillation to be set up within the cavity, by shock excitation, and as a result the potential between the two resonator grids varies at the carrier frequency.

Electrons passing the gap thereafter find themselves alternately accelerated and decelerated by this variation in potential. On leaving the gap, the variations in electron velocity persist, with the result that the faster electrons catch up with those which pass unaccelerated, while the slower electrons fall back on the unaccelerated ones. In consequence, the electron stream becomes bunched, that is, more dense in spots and less dense in others.

Meanwhile the electron stream encounters a decelerating d-c field applied by the reflector electrode (about −700 volts). This causes the electron stream to reverse its path, while the bunching process proceeds, and to re-enter the resonator gap. If the velocity of the electrons and the reflector potential are properly chosen with respect to the wavelength and the dimensions of the tube, the bunched electrons arrive back at the resonator gap just as the potential across the gap is such as to cause maximum retardation of the electron bunch. The electron bunch thereupon gives up a portion of its kinetic energy to the resonator.

As the succession of electron bunches re-enters the gap, the oscillations are successively reinforced until equilibrium is reached between the energy abstracted from the cavity (via the coupling loop shown) and the energy input to the beam less losses within the tube. Power levels in the hundreds of milliwatts are readily produced.

The frequency of oscillation depends not only on the natural period of the resonator, but also on the phase with which the returning bunches enter the gap, and this phase may be changed by adjusting the voltage on the reflector electrode. This electrical method of tuning is employed to tune the receiver precisely to the transmitter frequency. The tube will oscillate at several values of reflector voltage; the most negative value is generally chosen. Care is taken to stabilize the accelerating and decelerating potentials applied to the klystron, to avoid electrical detuning. Care must also be taken to avoid feeding too great an output from the local oscillator to the crystal detector, since excessive power absorption by the crystal will injure the rectifying interface. The local oscillator is coupled very loosely to the crystal by the flat probe electrode shown in Fig. 8, not only to minimize this danger, but also to prevent absorption of the echo pulses in the local oscillator itself, which is tuned within 1 percent (30 mc at 3,000 mc) of the carrier frequency.

The I-F Amplifier

The i-f preamplifier is coupled to the mixer through a transformer, but thereafter the i-f stages are coupled by single tuned circuits, inductively tuned. The inductive ele-

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ment is placed in the grid of the following tube, rather than in the plate of the preceding tube, to minimize the resistance in the grid return, which would prolong recovery after overload. Type 6AC7 high-g_m pentodes are used. The avc voltage is applied to the grid of the second stage.

The output of the preamplifier is conducted through flexible coaxial cable to the remaining i-f stages in the receiver proper. A simplified schematic of the i-f, detector, and video circuits is shown in Fig. 10. The 3rd, 4th, and 5th i-f stages are substantially identical to the second stage, employing 6AC7 tubes with single-circuit inductively-tuned coupling. The interstage coupling is loaded with the plate resistance of about 850 ohms, producing a gain of about 7 per stage across an overall band of 1.7 mc. The 3rd stage has avc.

The sixth i-f stage is a dual unit, one tube feeding the remote video amplifier outside the receiver chassis, the other leading to a 7th i-f stage. This latter (servo) channel operates under gate control, that is, the 6th servo i-f stage passes signal only during a brief period corresponding to the time the desired echo is received.

The function of gating in the automatic tracking circuits will be evident from the following. When the radar views more than one target simultaneously, as may readily happen in antiaircraft activity, a separate sequence of echo pulses is received from each target. The automatic tracking circuits have no way of distinguishing between these sequences of pulses and they tend to move from one target to another, or to seek a position midway between targets.

To avoid this confusion, the radar operator must select a target and see to it that the radar follows that target to the exclusion of all others. The target is selected initially on the PPI indicator and then identified as a particular echo pulse on the type J range scopes. Thereafter the operator adjusts a control which keeps a hairline centered on the echo selected. The control is connected to a pulse-forming circuit which develops a narrow rectangular pulse (narrow gate pulse) which occurs just prior to reception of the desired echo.

The narrow gate pulse is applied, in positive polarity, to the screen grid of the sixth i-f stage in the servo channel. In the absence of the narrow gate pulse, the screen grid is grounded and this stage remains inactive. During the narrow gate pulse, however, the stage is suddenly activated and passes the signal to the succeeding i-f stage and thence to the detector, video and servo-control circuits. The width of the narrow gate is normally about 3 microseconds, and is thus capable of cutting off all echoes outside a segment of about 3,000 feet in the range coordinate. A recent modification of the equipment consists of the so-called N^3 gate (N^2 for narrow-narrow), in which the control gate is only 0.5 microsecond long, corresponding to a segment in range of about 500 feet.

One other precaution must be taken in the automatic tracking system. If the amplitude modulation on the pulse sequence (which arises from off-axis targets as a result on the conical scanning, see part I) is not of constant amplitude, the comparison between reference voltage and error signal cannot be carried out successfully. Consequently it is necessary to apply an amplified automatic gain control voltage to the 2nd and 3rd i-f stages. This voltage is obtained by passing the pulse sequence from the servo channel output to a diode detector which develops the peak value of the amplitude-modulated pulse sequence. This peak value is amplified through a cathode-follower stage and applied to the i-f stages.

The timing and indicating systems will be described in the concluding installment of this series.—D.G.F.

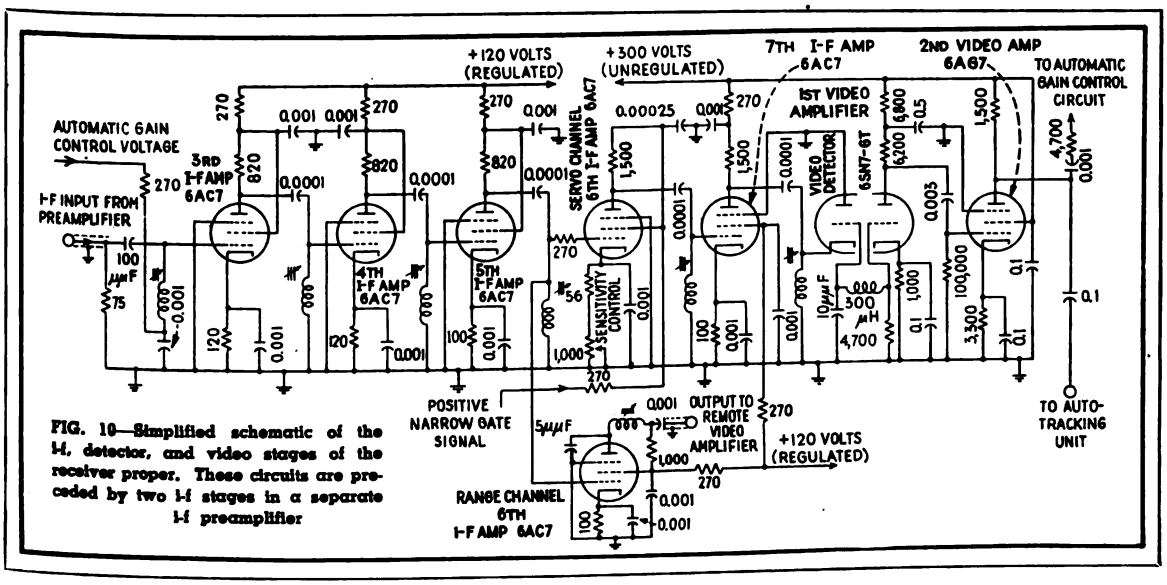

FIG. 10—Simplified schematic of the i-f, detector, and video stages of the receiver proper. These circuits are preceded by two i-f stages in a separate i-f preamplifier

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Loran Receiver-Indicator

Circuit details and operation procedures of the navigator's equipment, which establishes the position of ships or aircraft by measuring pulse time differences, are described in this second article of a series

THE receiver-indicator of the Loran system, as stated in the first article of this series', measures the difference in the time of arrival of a pair of pulses, displayed on a c-r oscilloscope.

The oscilloscope sweeps are synchronized with the incoming pulses by an independent quartz-crystal oscillator adjusted by the operator to exact synchronism. The pulses are approximately 40 microseconds wide at the half-amplitude level. To match such wide pulses to an accuracy of one microsecond, it is necessary to superimpose the waveform of one pulse directly over the other.

The pulse-matching procedure is illustrated in Fig. 1, which comprises photographs taken directly from the screen of the Loran indicator. In Fig. 1A the horizontal traces are sweeps each approximately 20,000 microseconds long, synchronized at 25 sweeps per second, or 15,000 microseconds long at 33⅓ pps. The upper trace is referred to as the master or A trace because on it is displayed the pulse from the master (A) station; the lower trace is the slave or B trace.

The pedestal on each trace represents a portion of the trace which is later expanded to reveal the pulse shape. The master pedestal is fixed in position at the left edge of the master trace. On it is displayed the master pulse. The slave pulse then falls somewhere to the right on the lower trace. The slave pedestal, whose position is adjustable, is moved until it falls directly under the slave pulse. These steps are illustrated in Fig. 1A through 1C.

When the set is first turned on, the pulses appear (Fig. 1A) in arbitrary positions, depending on the fortuitous phasing of the crystal synchronizing circuit relative to the incoming pulses. By slight adjustment of the crystal synchronizing frequency both pulses can be shifted left or right on the screen until the positions shown in Fig. 1B are found, i. e. with the master pulse on the master pedestal and the slave pulse below it and to the right.

The portions of the traces contained within the pedestals are then expanded (750-μsec sweep) by changing the sweep speed, with the result shown in Fig. 1D. By a fine adjustment of the slave pedestal control, the lower (slave) pulse is moved so that it falls nearly under the master pulse, and by adjustment of the crystal synchronizing control, both pulses are shifted to the left

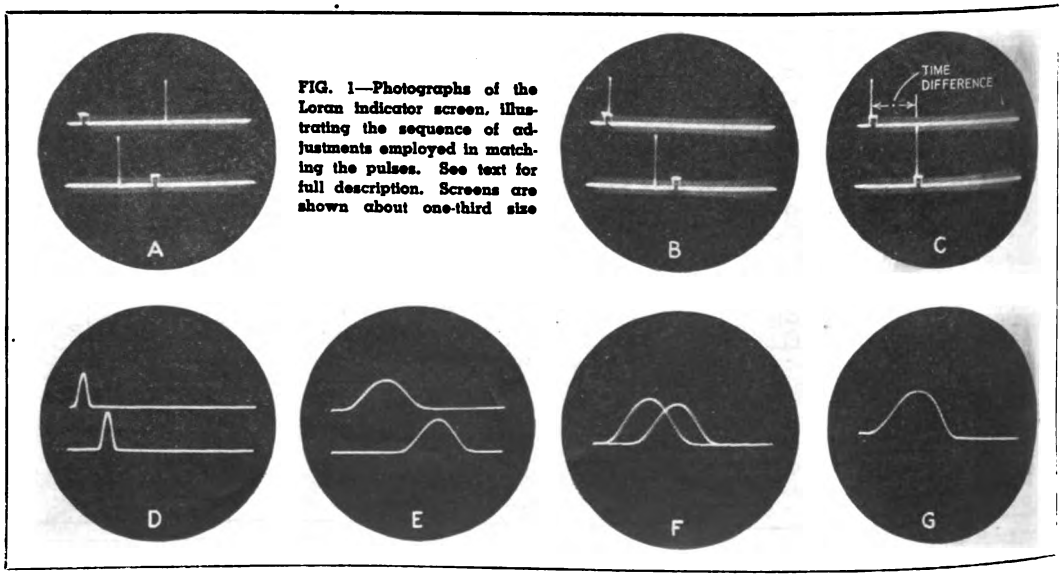

FIG. 1—Photographs of the Loran indicator screen, illustrating the sequence of adjustments employed in matching the pulses. See text for full description. Screens are shown about one-third size

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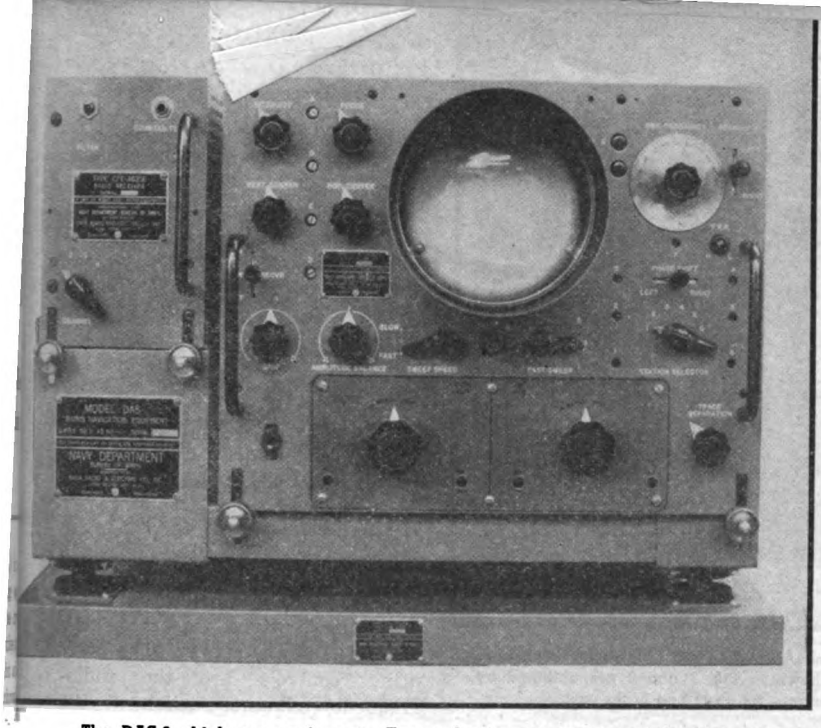

The DAS-3 shipborne equipment. Except for its greater size and weight this receiver-indicator is very similar to the AN/APN-4

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of the traces, as shown.

A second expansion of the traces (200-μsec sweep) is then introduced, as shown in Fig. 1E, and the two traces are then brought together (Fig. 1F). Any difference in the heights of the two pulses is corrected by a differential gain control. Finally, by further adjustment of the slave pedestal, the two pulses are brought into exact coincidence, as shown in Fig. 1G.

Reading the Time Difference

The time difference is measured by calibration marks, derived from the quartz crystal synchronizing circuit and imposed on the traces as shown in Fig. 2. By throwing a switch, after the pulse match of Fig. 1G is obtained, the pulses are removed and the calibration marks substituted. The time difference is read in three steps which indicate in succession the units and tens, hundreds, and thousands of microseconds.

In Fig. 2A the fastest sweep (corresponding to Fig. 1E) is shown with markers extending above and below each trace. The small upward markers indicate ten-microsecond intervals, and the larger downward markers indicate fifty-microsecond intervals. The units and tens are read by considering the lower trace as a scale and one of the upper markers as a pointer, reading from a large marker on the lower trace to the next larger marker to the right on the upper trace. The time interval indicated is 24 microseconds.

The sweep is then contracted one step to 750 μsec and the markers shown in Fig. 2B appear. The traces correspond to those in Fig. 1D. The largest downward markers mark 500-microsecond intervals. The hundreds of microseconds are read in the same manner as in Fig. 2A, that is, from a large marker on the lower trace to the next larger mark to the right on the upper trace, counting in steps of 50. The partial time difference indicated is 350+ where the plus sign indicates the partial time difference previously read, 24 microseconds. Hence the total time difference, thus far measured to the hundreds, is 374 microseconds.

Finally the sweep is contracted to its original length, 20,000 μsec, corresponding to Fig. 1C. The markers then appear as shown in Fig. 2C. Each trace is divided into groups of 2,500 microseconds. The thousands of microseconds are read from the upper pedestal to the lower, in groups of 500. The partial time difference indicated is 3,500+, where the plus sign indicates the partial time difference, 374 microseconds, previously measured. The total time difference is then 3,874 microseconds.

This apparently involved method of measurement is not so complicated in practice as it appears when described verbally. The complete process, indicated in Fig. 1 and 2, can be carried out in less than a

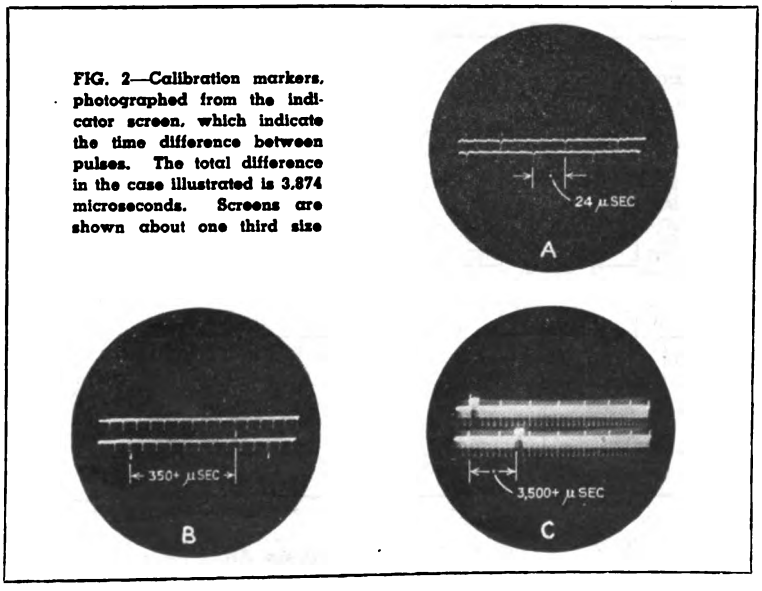

FIG. 2—Calibration markers, photographed from the indicator screen, which indicate the time difference between pulses. The total difference in the case illustrated is 3,874 microseconds. Screens are shown about one third size

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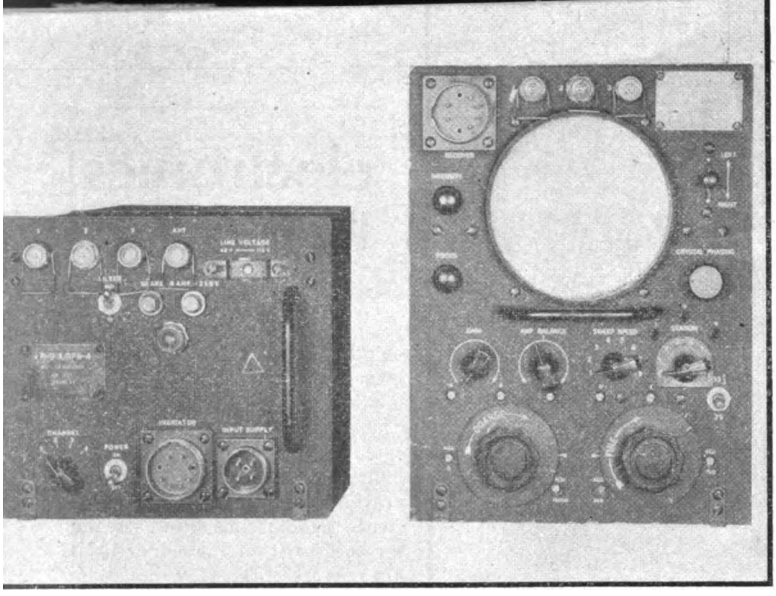

FIG. 3—Receiver (left) and indicator of the AN/APN-4 airborne receiver-indicator equipment. The sequence of patterns shown in Fig. 1 and 2 are obtained by manipulation of the indicator controls, as described in the text

minute by a well-trained operator, or in ten or twenty seconds by an expert.

The foregoing steps are then repeated on another pair of stations. The pulses from the second pair of stations are sent out at a slightly different pulse rate, (say 25⅓ pps) but on the same radio frequency. Hence these second pulses are visible during the foregoing operations, but move rapidly across the screen, since the sweeps are not synchronous with them. The motion is sufficiently rapid that the second pair of pulses does not interfere with the measurement of the first.

To measure the second pair, the sweep rate of the indicator is switched to the rate corresponding to the second pulse rate. The second pair then remains stationary, and can be measured as above while the first set is in motion. In some regions of the world, as many as 6 pairs of pulses, each pair on a different rate but the same radio frequency, can be seen simultaneously. The identification of the pair being measured is made by noting the rate at which the c-r sweeps are set. The sweep-speed switch is marked with station-pair numbers which correspond with similar numbers marked on the Loran chart. The complete identification and time difference reading is given in several characters, a typical example being 1L1-3874. The figure 1 refers to the radio frequency (1 = 1,950 kc), the letter L to the basic pulse rate (L = 25 pps), 1 to the specific pulse rate (L1 = 25⅓ pps), and 3,874 is the time difference (typified in Fig. 2).

External Appearance

The external appearance of a typical airborne Loran receiver-indicator type AN/APN-4 is shown in Fig. 3. The smaller unit contains the receiver proper and the regulated power supply. The operating controls are the radio-frequency channel switch at the lower left (whose numbers correspond to the first digit in the identification symbol) and the power switch. The larger unit is the indicator, which comprises the c-r oscilloscope and its associated timing and sweep circuits. The two small knobs, upper left, control the brilliance and focus of the c-r trace. The toggle switch, upper right, introduces small changes in the crystal frequency and thus shifts the pulses to left or right. Below it is the crystal-frequency control knob which is adjusted to bring the sweep traces into exact synchronism with the incoming pulses.

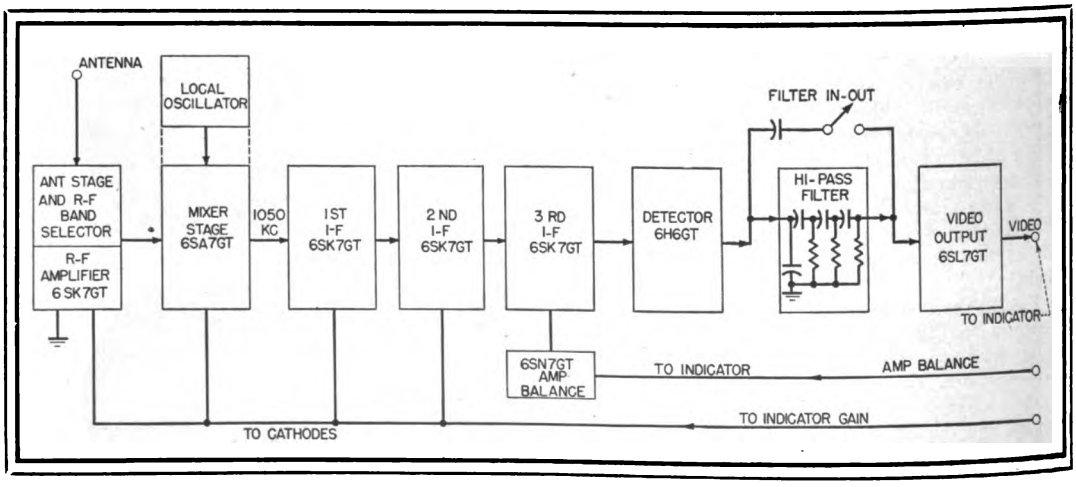

FIG. 4—Block diagram of the AN/APN-4 receiver. The circuits are conventional except for the differential gain control applied to the third i-f stage

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The operating controls just below the c-r tube are overall gain, amplitude balance, sweep speed and station selector. The first controls the height of both pulses as they appear on the screen, whereas the second is a differential gain control which adjusts the height of one pulse relative to the other, as required in the matching procedure. The sweep speed selector introduces the successive changes illustrated in Fig. 1 and 2. The station selector selects the specific sweep rates to correspond to the discrete pulse rates of the different station pairs.

The two large knobs at the bottom are left to right the coarse and fine controls which shift the position of the slave pedestal in the matching procedure. The switch at the lower right selects the basic pulse rate, L for 25 pps and H for 33⅓ pps. The various controls are so arranged and marked that a glance at the settings gives the first three digits of the identification symbol. The AN/APN-4 weighs about 65 pounds and consumes about 275 watts, 400-2,400 cps, 80 or 115 v.

Several other Loran receiver-indicators have been developed. The DAS-3, the basic equipment used by the Navy aboard ship, is somewhat larger and heavier, and has a different arrangement of controls, but is otherwise similar to the AN/APN-4. It operates on 60-cps power. The AN/APN-9 is a more recent version for airborne use. It employs a three-inch c-r tube and non-linear sweeps which make possible a reduction in the number of tubes in the indicator circuit. It weighs 35 pounds and consumes about 175 watts, 400-2,400 cps. The method of matching the pulses differs in detail, but not in principle, from that described here.

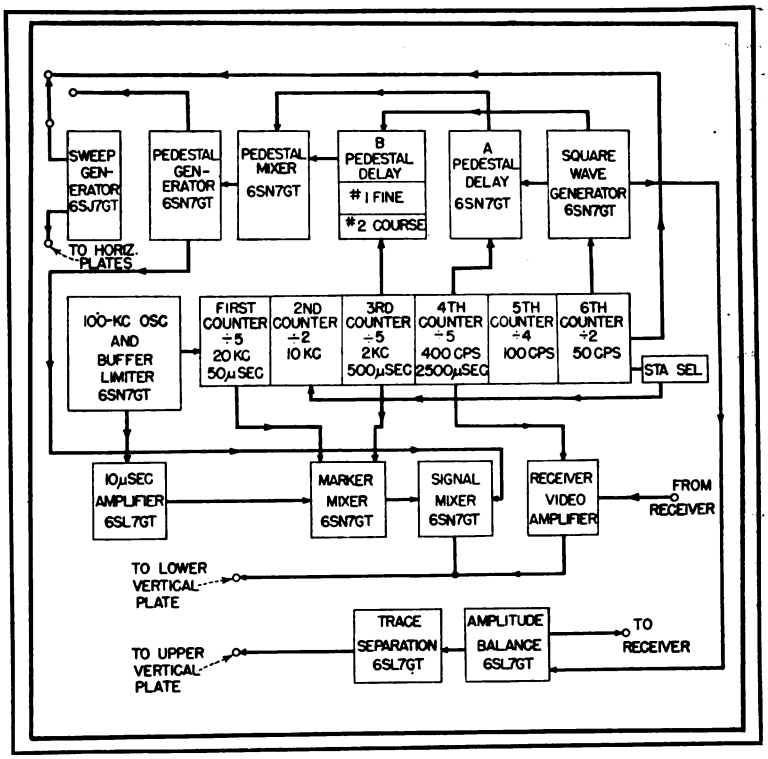

FIG. 5—Block diagram of the AN/APN-4 indicator. The 100-kc crystal timing source is converted by counter circuits to 25 or 33⅓ cps rectangular waves which control the sweeps and pedestals

Details of AN/APN-4 Receiver

The receiver of the AN/APN-4 (Fig. 4) is a wide-band superheterodyne, employing three i-f stages. The 6SK7 r-f amplifier and 6SA7 mixer-local oscillator are conventional, being tuned by a switch which selects four channels at 1,750, 1,850, 1,900 and 1,950 kc. The three intermediate-frequency stages (type 6SK7 tubes) operate at 1,050 kc, and have a bandwidth of approximately 60 kc at the 6-db (voltage) level. This bandwidth is somewhat narrower than the spectrum of the transmitted pulse, but permits reproduction of the pulse with the shape shown in Fig. 1G, with 40-microsecond width at the half-amplitude points. A 6H6 diode demodulates the i-f signal and transmits the pulses to the 6SL7 video amplifier, which feeds the indicator.

The cathode of the last i-f stage connects with the indicator from which is supplied a rectangular wave of voltage synchronous with the sweep traces. This rectangular wave passes through a cathode-follower stage and biases the last i-f stage on the negative half-cycles, thus reducing the gain of the receiver during the formation of one c-r trace, while allowing normal gain during the formation of the other trace. The amplitude and polarity of the rectangular wave are controlled by the amplitude balance control previously mentioned.

Two high-voltage supplies are contained within the receiver housing. One is a 2,600-volt low-current supply for the cathode-ray accelerating electrodes, arranged in two sections of 1,300 volts each, above and below ground. The low-voltage power is supplied at 260 volts, accurately regulated.

Details of AN/APN-4 Indicator

The indicator circuits are illustrated in the block diagram in Fig. 5. The basic timing source is the 100-kc quartz crystal oscillator. Across the crystal is a small variable capacitor which permits small adjustments of the crystal frequency. From this 100-kc source, the sweep traces at 25 pps or 33⅓ pps must be obtained together with the minor varations in these rates corresponding to the different specific pulse rates of the station pairs. the derivation of the 25 or 33⅓ cps wave from the 100-kc source is accomplished by a series of frequency-divider circuits. A total frequency division by 4,000 (in seven steps of 5, 2, 5, 5, 4, 2, and 2) is required to derive the 25-cps rate, and by 3,000 (5, 2, 5, 5, 3, 2, and 2) for the 33⅓ cps rate. The first six divisions are performed by counter circuits, the last factor of 2 by an Eccles-Jordan scale-of-two circuit.

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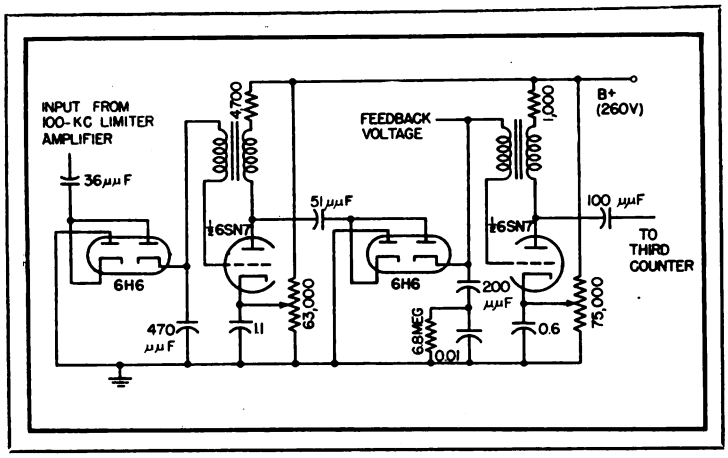

FIG. 6—First and second counter stages of the indicator, which divide the 100-kc input by 5 and 2, respectively. Four additional counters are used to introduce a total division of 4,000 for the 25-cps sweep or 3,000 for the 33⅓ cps sweep

Two of the six counter circuits are shown in Fig. 6. The 100-kc output from the crystal, having passed through a limiter amplifier, is fed to a 6H6 double diode so connected that it passes negative pulses to ground while passing positive pulses to a capacitor, and the voltage across it thereby increases in steps. When five such steps have been accumulated, the voltage across the capacitor has reached a sufficient level to trigger the following circuit, a 6SN7 blocking oscillator.

The blocking oscillator generates one pulse and discharges the capacitor in the process, which thereupon accumulates five more pulses from the 100-kc source and triggers off the blocking oscillator once more. Thus the blocking oscillator reacts once for each five input pulses and the frequency is divided by five.

The output of the blocking oscillator is applied to another double diode which, like the first, passes the positive pulses to a capacitor which charges to the level of two steps and thereupon triggers off a succeeding blocking oscillator (biased to respond to two steps). In all, six double diodes and six blocking oscillators are used in sequence to introduce the divisions previously enumerated.

The functions of the Eccles-Jordan circuit are numerous. First, the rectangular output constitutes the wave, previously mentioned, which provides differential gain control of the receiver during the formation of the two traces. The same wave, applied through a 6SL7 "trace separation" stage to the vertical deflection plates of the c-r tube, causes the slave trace to be displaced vertically from the master trace. Finally, the Eccles-Jordan wave, after passage through appropriate delay circuits, controls the formation of the master and slave pedestals, as outlined below.

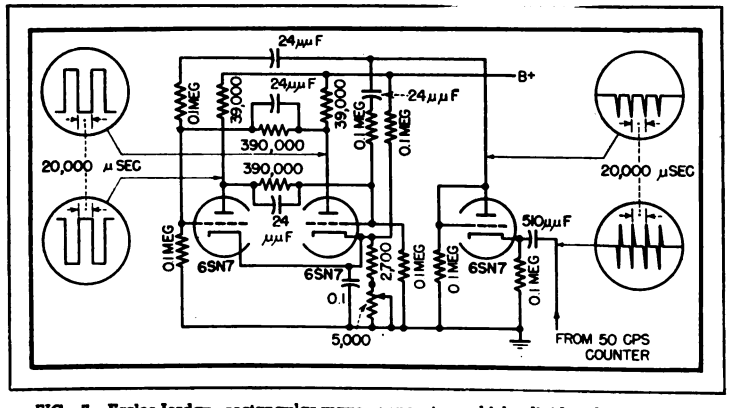

FIG. 7—Eccles-Jordan rectangular-wave generator which divides by a factor of 2 and provides rectangular waves at 25 or 33⅓ cps for controlling the sweeps and pedestals

Eccles-Jordan Circuit

The Eccles-Jordan circuit (Fig. 7) is similar to a conventional multivibrator, except that the grids and plates of the two triode sections are interconnected by conductive coupling. The circuit does not relax in the usual fashion of a multivibrator, but has two conditions of stable equilibrium. The circuit remains in equilibrium until the synchronizing pulse is received, causing the two triodes to exchange polarities suddenly. The circuit remains in this condition until another pulse causes a reversal to the original condition. The sync pulses, as they arrive from the last counter, display negative as well as positive polarity. These pulses are passed through a 6SN7 connected as a diode, which removes the negative pulses and passes the positive pulses to the Eccles-Jordan circuit.

Other Functions of Counter Circuits

Several additional functions of the counter circuits must be described. First, the counter circuits supply the calibration marker pulses. The 10-μsec markers are derived from the 100-kc source directly, the 50-μsec pulses from the first counter output (20 kc), 500-μsec markers from the third counter (2 kc), and 2,500-μsec markers from the fourth counter (400 cps). These markers, in proper relative amplitudes, are combined in a mixer stage and applied to the vertical deflection plates of the c-r tube.

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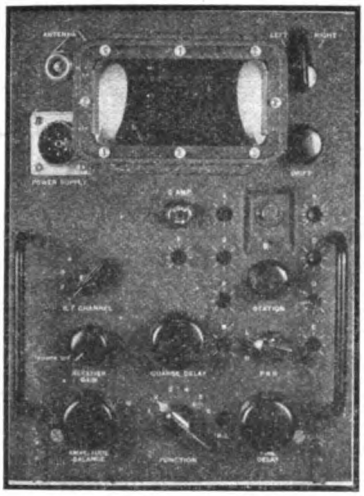

The AN/APN-9 airborne receiver-indicator. The use of a 3-inch tube and nonlinear sweeps reduces size and weight to a single unit weighing about 35 pounds

The slight variations in the basic pulse rate (amounting to multiples of 0.25 percent of the pulse rate) are introduced by a feedback connection from the last counter stage to the input of the second counter stage. Additional voltage is thereby supplied to the steps of voltage accumulating at the input of the second counter, causing the second counter to fire ahead of the normal time by a slight amount. This produces a corresponding small increase in the final frequency. The amount of voltage fed back is controlled by a switch, in eight discrete levels. The corresponding sweep rates are 25, 25 1/8, 25 2/16 and so on to 25 7/8 sweeps per second, and similar values for the 33 1/3 rates.

Finally, the counter stages are used to synchronize the pedestal delay circuits so that the master pedestal always occurs at a given 500-microsecond marker and the coarse delay control moves the slave pedestal in 500-microsecond jumps.

Pedestal Circuits

The pedestal delay is introduced by a 6SN7 multivibrator circuit triggered off by the leading edge of the Eccles-Jordan output square wave. After a delay determined by its relaxation time, the multivibrator generates a pulse which in turn controls the formation of the slave B pedestal. By adjusting the resistance component of the multivibrator time constant, the delay thereby introduced may be varied from 20,000 to approximately 32,000 microseconds. The corresponding positions of the slave pedestal are directly below the master pedestal and some 12,000 microseconds to the right. This range covers the values of time difference to be measured between the incoming pulses.

A similar fixed-delay multivibrator causes the master (A) pedestal to appear in a fixed position shortly after the beginning of the master trace. The output waves of the A and B delay multivibrators are combined in a mixer and applied to the pedestal generator which produces short (150-μsec) square waves. On the slow sweep (Fig. 1A through 1C) these waves are combined with the traces to form the pedestals. On the fast sweeps (Fig. 1D through 1G and Fig. 2), the leading edges of the pedestals are used to trigger the sweep generator.

The sweep generator itself (Fig. 8) develops a linear sweep voltage by charging a capacitor across a constant-current series pentode, synchronously with the sweep control voltage (Eccles-Jordan output for slow sweep, pedestal generator output for fast sweeps). The saw-tooth deflecting wave is passed through a 6SN7 paraphase amplifier which develops two symmetrical sweep voltages of opposite polarity, which are applied to the respective horizontal deflection plates. The cathode-ray tube circuits are in the main conventional.

In the concluding article of this series, the shore-station equipment, including transmitter and radiating system, timer and synchronizer, will be described.—D.G.F.

Reference

(1) The Loran System, Part I, ELECTRONICS, p 94, Nov. 1945.

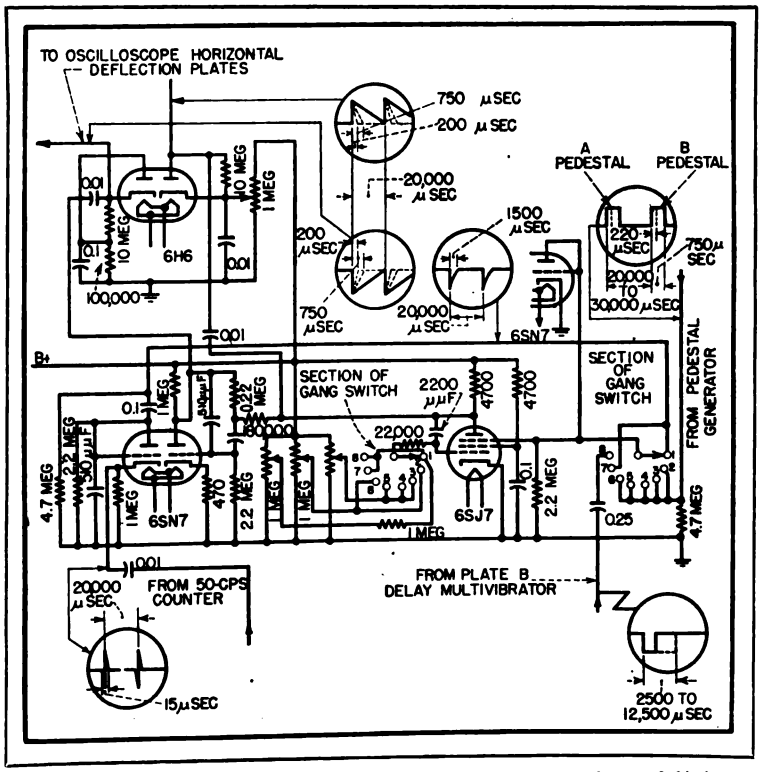

FIG. 8—Sweep generator which produces the saw-tooth waves (upper left) for the 20,000, 750, and 200 microsecond sweeps shown in Fig. 1 and 2. The 6SJ7 constant-current pentode develops a linear sweep voltage between its plate and ground

electronics war report

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GEOPHYSICAL

Electronic circuits used today include variable-sensitivity amplifiers for the recording galvanometers, accurate time control for the recorders, and time marking for indicating the time and depth of shot that is fired to produce ground waves

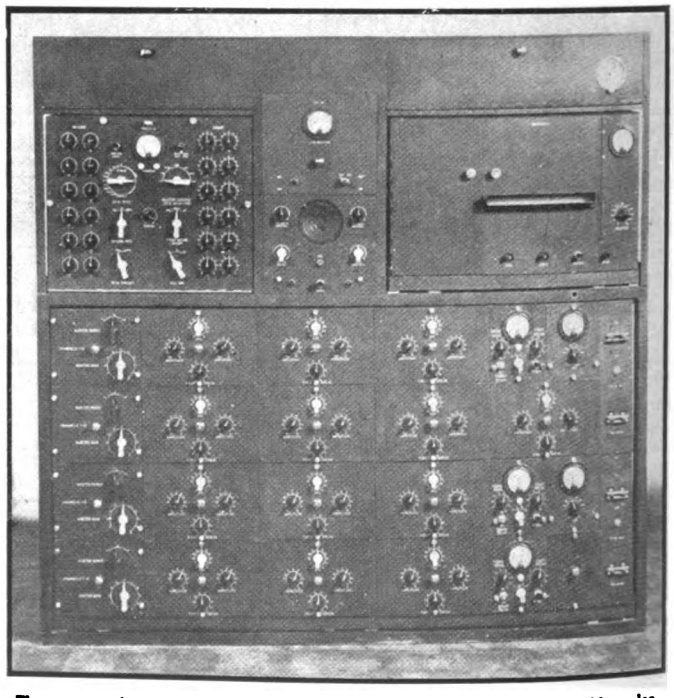
By DAVID SHEFFET
Stanolind Oil and Gas Co.
Tulsa, Okla.

THE OIL INDUSTRY relies heavily on the electronics industry for many products. In the geophysical division alone there is a broad use of electronic components. At the present time there is an estimated annual expenditure for geophysical exploration of approximately four million dollars on the products of electronic manufacturers. Although this sum seems small compared with the astronomical output of manufacturers during the war, it represents a steady reliable market which is not likely to be reduced by the advent of peace. On the contrary, the persistent search for new scientific methods and techniques by the oil industry is likely to broaden the demand for electronic components.

Prospecting Methods

Practically all geophysical exploration for petroleum at present employs three basic methods of prospecting. These methods are seismic, gravimetric and magnetic. All three methods are used by oil companies in a complete exploration program. The gravity and magnetic methods are relatively inexpensive and fast in operation, and are used as reconnaissance methods to give a quick overall picture of an area. They do not provide accurate subsurface detail, but serve to outline general limited

The recording equipment of the seismometer installed in the truck



The operator's panel includes terminal positions from seismometer cables, electrical test set, timing circuits, amplifiers, recording oscillographs, and firing controls

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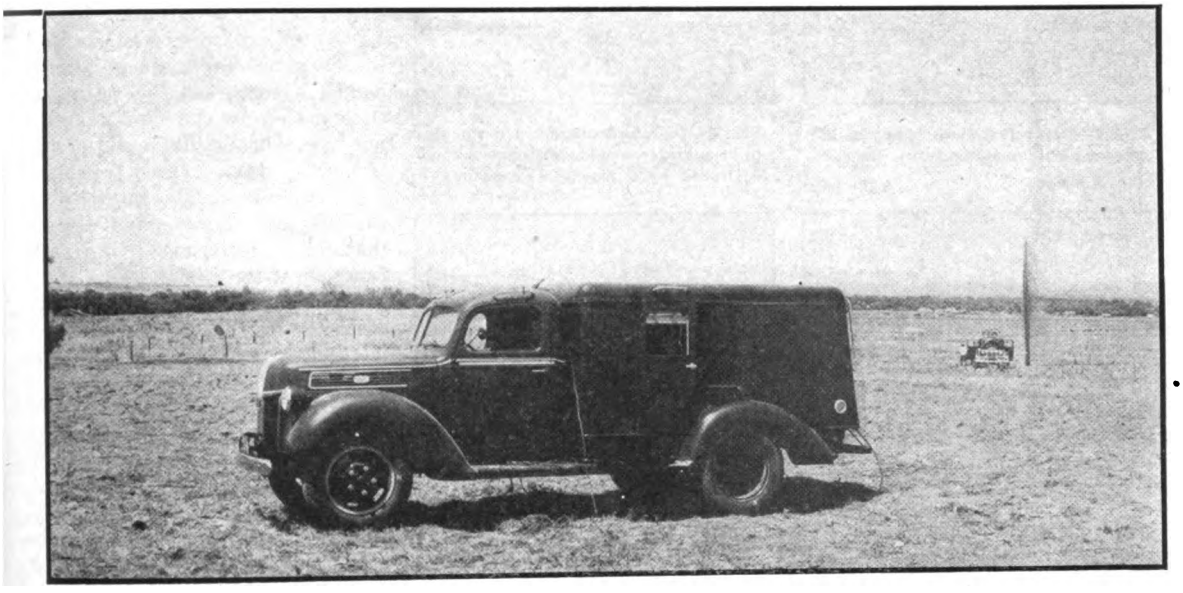
PROSPECTING EQUIPMENT



The truck for field surveys carries the recording equipment. In the background is the shooting truck beside a geyser of mud and water blown out of the hole as an aftermath of the shot

areas of interest which can later be more accurately delineated by the seismograph.

The gravity meter is an amazingly sensitive device for measuring the variations of the force of gravity with variation of geologic structure. However, all of its remarkable magnifying properties are obtained by means of mechanical and optical linkages. The electrical circuits involved are usually associated with simple relays for maintenance of limited temperature fluctuations.

The magnetic method involves the use of a magnetometer which is a combination magnetic, mechanical, and optical device for measuring the variations of the vertical magnetic field associated with geologic formations.

Of the three methods, the seismic method has borrowed the most from the electronic field. What is usually known as the seismograph actually is a system comprising a large group of earth-type microphones, cables, control circuits, amplifiers and a recording oscillograph. In addition, there are voice communication circuits and shot-firing circuits. All this equipment is used to record the vibrations generated in the earth by firing a charge of dynamite below the surface. The acoustic waves initiated by the explosion penetrate the geologic formations and produce reflected waves at the boundaries between different media because of sudden changes in elastic properties (acoustic impedance) across the boundary zones. These reflected waves return to the surface of the earth and are recorded so as to indicate depth and dip of the various reflecting horizons.

Seismograph Field Spread

In a seismograph field setup, or spread as it is usually known, a group of 24 or more seismometers (ground-contact microphones) is placed on the earth in a line either running through the shot point or offset from it. The exact arrangement and number of these seismometers and configuration of the spread varies considerably between companies and between different areas surveyed by a given company. As few as 12 and as many as 96 seismometers have been used by some operators. The length of the spreads may vary from 200 feet to 3,000 feet. It is important in any spread to know the exact distances between seismometers and shot point because these enter into the final calculations of depth and dip of the subsurface strata.

Amplifiers

The seismometers connect through multiconductor cables to a control and test panel in the recording truck. This control panel feeds the outputs of the seismometer groups to a large number of identical recording amplifiers. These amplifiers connect to a multiple galvanometer recording oscillograph which records the output of each channel on sensitized photographic paper. It is common practice at present to use 12 or 24 amplifier channels and a single galvanometer block in the oscillograph, which contains a corresponding number of recording elements plus a spare.

There are many kinds of seismic

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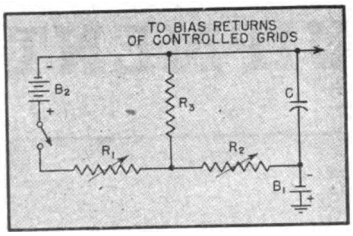

FIG. 1—Time-rate volume expander increases gain of amplifiers after the shot is fired

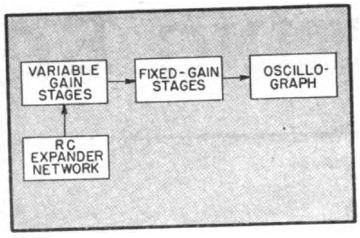

FIG. 2—To record all reflected signals at comparable amplitudes, gain is controlled by a time-rate expander

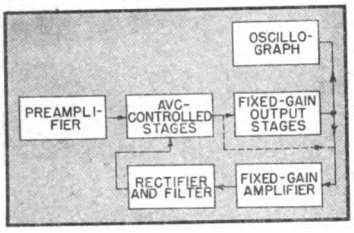

FIG. 3—For maintaining constant input to the oscillograph, avc can be obtained from the amplifier output

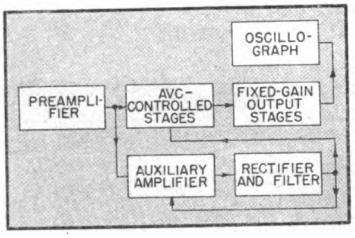

FIG. 4—A loop containing an auxiliary amplifier can provide over- or under-control for avc

amplifiers in use by geophysical companies. Most of them use automatic volume control or adjustable time-rate expanders or combinations of both. In seismic shooting the range of input signal which must be recorded varies as much as 10,000 to 1, according to the area worked. This wide amplitude range must be reduced to an average range of 2 to 1 or better at the oscillograph, and this must be done in a period that rarely exceeds four seconds and is often as short as one second. The threshold sensitivity of the amplifier should be adjustable in steps between one microvolt and one millivolt. This requirement means that when the amplifier is wide open, any signal above the threshold value of one microvolt will operate the automatic volume control. With the gain reduced 60 db, signals have to exceed the threshold of one millivolt to operate the avc. These are common requirements today for fully automatic volume-control systems.

Preadjusted time-rate expanders in which the gain varies with time are also used. In this system some variable gain elements such as remote-cutoff pentodes have their bias set at a predetermined level, thereby reducing the amplifier gain to the point where the initial high output of the seismometers after the explosion is fairly well controlled. At a definite time after the initiation of the shot, the bias is reduced at a predetermined rate by a capacitance-resistance network so that the gain of the amplifier increases while the energy of vibrations from the earth is decreasing. It requires experience in each area to know just what rate of gain expansion is necessary to compensate for the decrease of shot energy and obtain a uniform record. This experience is not so necessary when using a truly automatic volume control, therefore many operators today employ automatic volume-control amplifiers.

Gain Control

Figure 1 shows a circuit of a resistance-capacitance expander network such as is used in the time-rate expander system given in the block diagram of Fig. 2. When the switch is closed, capacitor C is charged to a voltage determined by adjustment of R_1. This voltage plus B_1 is the initial bias on the grids of the controlled tubes. The firing of the shot operates a relay which opens the switch; C discharges through R_3 and R_2. R_2 is adjustable so that the rate of gain increase can be set to match the expected rate of decrease of signal energy. Battery B_1 represents the final bias reached and determines the maximum gain of the amplifier when the capacitor has discharged.

One ingenious variation of the time-rate expander system uses the resistance-capacitance gain expander system, but the resistance that discharges the capacitance is not fixed during the period of the record. Instead, the resistance itself is electronically controlled by the average signal amplitude, so that the gain expansion rate is a function of the signal. This characteristic is like a one-way avc because the gain of the amplifier can increase when signal level decreases, but cannot decrease if signal level temporarily increases because the expander capacitor cannot recharge once it has started on its discharge cycle.

In the development of automatic volume control for seismic recording, the problem at first seemed simple because avc was already being used in radio receivers quite successfully. The thing that made it difficult was the fact that the major frequencies recorded were between 25 and 100 cycles. In radio receivers the stages controlled by the avc voltage operate at several hundred kilocycles or in the megacycle range. The rectified and partly filtered intermediate-frequency voltage which supplies the avc bias has no residual components that are likely to be amplified by the stages which it controls. Thus there is excellent protection against oscillation of the system at one of the fluctuation component frequencies.

Avc Problems

In a seismic amplifier the frequencies amplified are so close to the highest equivalent control frequency of the avc voltage that it is not a simple matter to obtain a wide amplitude range of control with sufficient speed of control and still maintain stability. The way in which the rectified avc voltage is filtered is very important. Too much filtering insures stability but reduces the rate of avc action. In some shooting locations this slowness does no harm but in others the avc cannot follow the rapid dynamic changes of the shot

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energy. Too little filtering produces instability which may vary from intermittently-appearing low-frequency rolls to continuous low-frequency oscillation. It is even possible to get good stability when the shot energy is medium to high, but get low-frequency incipient oscillations when the signal input is low.

Not only is the method of filtering important, but the type of variable elements controlled by the avc voltage is equally important for successfully attaining smooth dynamic action with dependable stability. The obvious control elements are variable-gain tubes such as the 6K7G or 6U7G. In a single-ended amplifier using the signal output to supply the avc voltage, these tubes can be controlled over a reasonable range with fair dynamic action. The avc voltage can be applied either to the control grids or to the suppressors. When applied to the control grids, the filtering is usually more critical than when the avc bias is applied to the suppressors. If the gain in the avc loop exceeds unity at any frequency where the input and output are in phase, the system will oscillate.

Figure 3 shows a block diagram of a typical automatic volume control amplifier. In this figure the preamplifier is a fixed-gain amplifier. However, this amplifier may also have its gain varied with time as shown in Fig. 2 or it may be included in the avc loop along with the succeeding stages of Fig. 3.

Another type of avc that has been used is the input type of control shown in block diagram in Fig. 4. In this system there is no feedback of output signal to be rectified and filtered for avc bias. Because the bias is generated by the input signal through a separate amplifier, the control action is independent of the output signal and consequently it is possible either to over-control or under-control the output. It is easily possible to produce zero output with a large signal input unless precautions are taken. One method of avoiding this effect is to let the auxiliary amplifier avc itself to a small extent.

The advantage of this system is absence of possible feedback in the controlled stages of the main amplifier and therefore reduction of the amount of filtering necessary in the avc filter. Thus greater speed of avc action is possible with good stability. The chief disadvantage of this system is that it requires careful matching of tube characteristics between the tubes in the main amplifier and in the control amplifier. If the tube characteristics vary with age it is possible to get both over-control and under-control on the same record. In the feedback or output control system of Fig. 3 a certain amount of tube variation can be tolerated because of the self-compensating characteristics of the feedback system. If the gain in the feedback loop should change with age or with power supply voltage variation, the worst that can happen is a uniform gradual under-control which does not show too badly except at large signal levels. It is impossible to over-control with an output control type avc system.

Electronic Variable Resistor

A method of control which is very popular in seismic recording makes use of electronic resistors as a part of an attenuator pad between amplifier stages. The 6H6 or 7A6 double diode can be used as an electronically controlled resistor with the avc bias voltage supplying the control. This circuit is shown in Fig. 5.

In a diode the plate is so close to the cathode that some emission from the cathode flows to the plate without any external voltage being impressed on the plate. Not all electrons flow to the plate, but there are so many of sufficiently high initial velocity that they strike the plate in great numbers and we call the result a high contact potential. When no external voltage is applied between plate and cathode, the resultant electron stream can be used as a low resistance. Biasing the plate negatively with respect to the cathode reduces the electron flow and increases the plate-to-cathode resistance. The range obtained varies from about 1,000 ohms to several megohms. It is necessary to use a back-to-back arrangement of diodes in order to prevent distortion over a wide range of signal voltages. It is possible to use a single half-wave diode over a limited range of signal levels. Con-

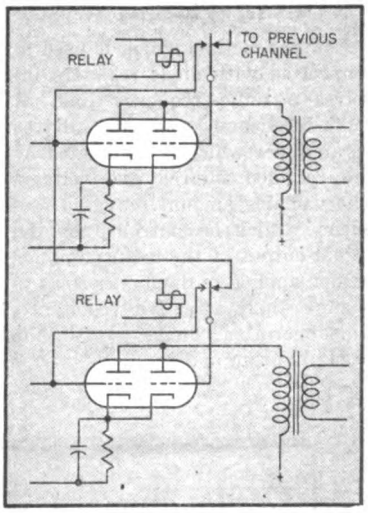

FIG. 7—Circuit for introducing overlap in the seismic record

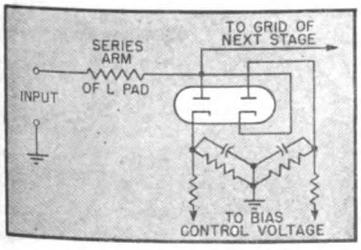

FIG. 5—Controlled duodiode is used as a variable resistance in an avc system

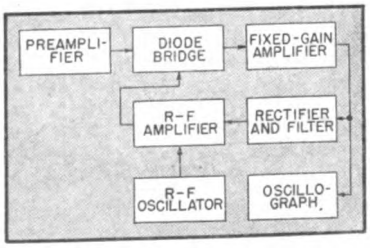

FIG. 6—A radio-frequency link can be used to control the diode resistor

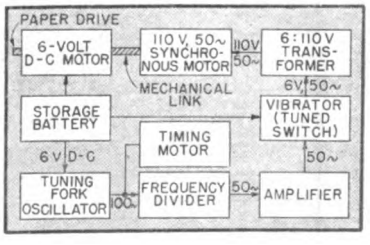

FIG. 8—Paper drive is held constant by the time-marker tuning fork

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tact rectifiers such as copper-oxide and selenium rectifiers can also be used in a manner similar to vacuum-tube diodes.

One of the big advantages of the diode system is the fact that the avc voltage is applied to the diodes in a balanced bridge connection. If the bridge is well balanced, any residual low-frequency component in the avc bias voltage will not appear between the output terminals of the bridge which connect to grid and ground of the following stage. This means that less filtering is required after the avc rectifier in the diode control system. Therefore, it is possible to obtain greater speed of avc action for a given amplitude control ratio with the diode system than with variable-gain pentodes. In any system, the closer the degree of amplitude control, the greater must be the gain in the avc loop and the more the filtering required to maintain stability. Increasing the filtering reduces the rate of control.

Methods of Applying Avc

Another method which is used in connection with diode resistors involves a radio-frequency link. A radio-frequency oscillator drives an amplifier which is modulated by the rectified filtered avc voltage. The variable amount of radio frequency which is controlled by the signal output of the main amplifier is then applied to the diodes so as to change their effective resistance. This operation can be seen in the block diagram of Fig. 6.

Still another method which is in present use in seismic recording dispenses entirely with thermionic elements in the controlled stages. Tiny lamps are used in a balanced-bridge arrangement to control the amount of signal passed through the amplifier. The variation of control is obtained by applying current at radio frequency (or any frequency very high compared with the seismic frequencies) to the tiny resistance elements. The amount of high frequency current which is applied is controlled by the rectified and filtered seismic frequencies near the output of the amplifier.

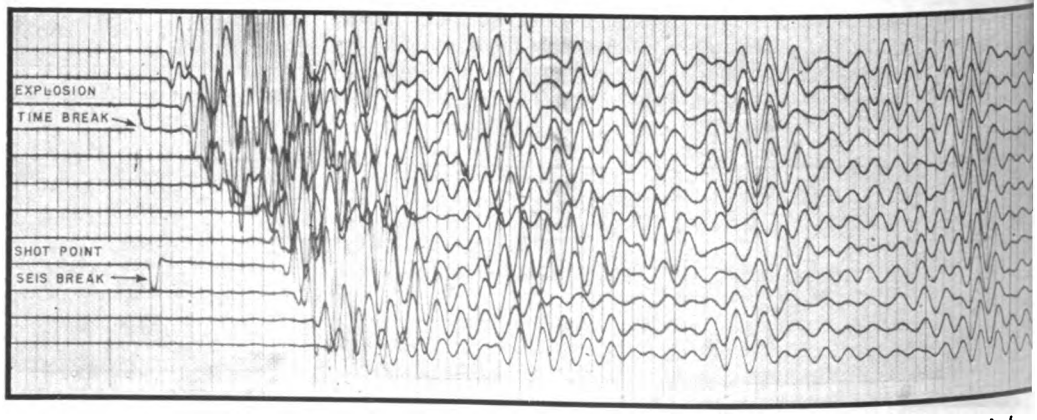
There is considerable variation in methods of overall control of a large number of channels. Some companies prefer individual avc complete in each amplifier channel. Others use a single master avc amplifier which receives its input signal from the combined outputs of several channels and supplies a form of average control bias equally to all channels. Another method is to pair adjacent channels and have a common avc amplifier controlled by the outputs of both channels produce a common control bias for both channels.

There are many combinations of simplified control. They have the advantage of saving parts and therefore space, weight, and cost. The disadvantage is in the much closer matching of control tube characteristics and the necessity of changing tubes more often. Where each channel has its own independent avc system, much greater variation in tube characteristics can be tolerated. Variations with use do not show up badly on the recording paper because there is partial compensation for gain variations when the avc control bias of an amplifier is a function only of its own signal output. Another disadvantage of master avc systems is in the wide initial variations in signal levels between different channels on certain types of long seismometer spreads.

Use of Filters

In all seismic amplifiers there must be a certain amount of tuning to discriminate against unwanted frequencies that mask the desired seismic frequencies. The desired band falls between 25 cps and 100 cps. This band is usually cut into smaller bands of interest according to the area in which the exploration occurs. Methods of filtering vary considerably between companies. Some use fixed band-pass filters of the conventional variety and some use combinations of high- and low-pass filters, with both upper and lower cutoff points adjustable by front panel control. Some use empirically shaped filters whose characteristics were determined from years of field experience in many shooting areas. These filters are unconventional in that the slopes above and below the center frequency may be widely different from each other.

It has been found highly advantageous in many areas to secure seismograms using different filters.



Portion of a seismogram, showing the time break of the explosion, the shot-point seismometer break, and the arrival of

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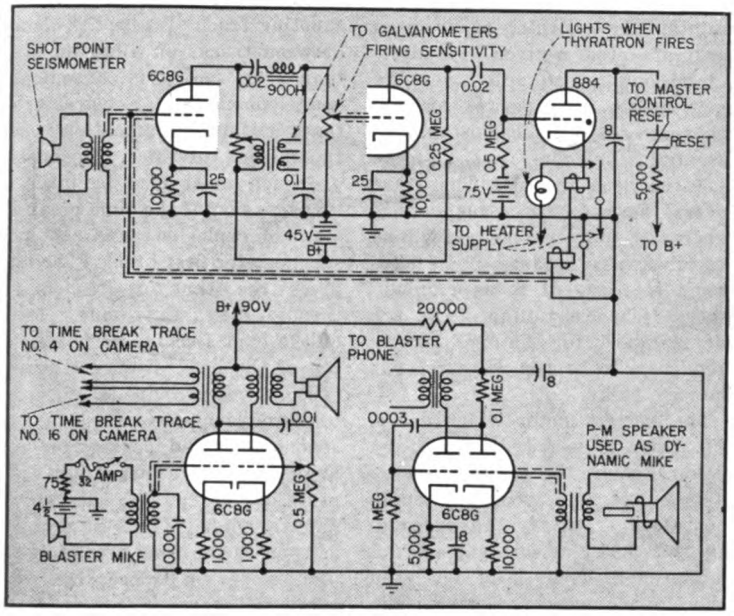


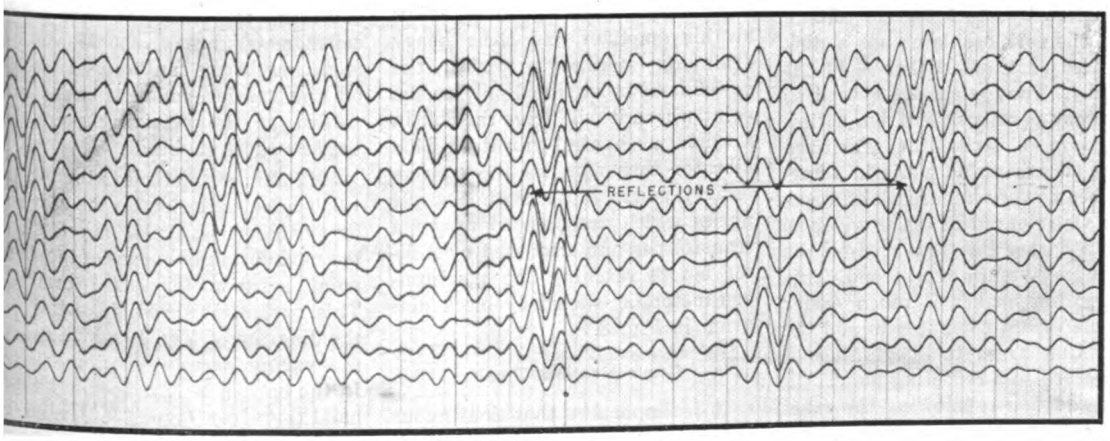
FIG. 9—Communication circuit for field use picks up essential information of the blast itself

Two or more shots can be recorded with different filter settings. Recently some operators have employed two or more sets of amplifiers to obtain two or more records simultaneously with different filters on the same seismogram. This practice has the advantage of reducing dynamite- and other operating-costs. Twelve amplifiers are used for the output of all seismometers on the spread in one filter setting and twelve others in another filter setting, known as dual recording. Triple and quadruple recording have also been used. Many times, information is gained from the combination record that would not have been evident from a seismogram secured with a single filter.

Phase Distortion Limitations

The amplitude and phase distortion requirements in a seismic amplifier are far more critical than in an ordinary audio amplifier. Seismic amplifiers are designed to have a certain type of frequency discrimination and with it goes a certain unavoidable amount of phase distortion. One of the practical difficulties in making a large number of amplifier channels is that of making them all alike in amplitude and phase response. In conventional audio amplifier work, listeners may disagree as to whether two amplifiers sound alike or not. In seismic recording the slightest difference between two amplifiers appears immediately on the seismogram and leaves no room for doubt. Amplifiers are therefore carefully matched for phase and amplitude response. No frequency component of interest must vary more than one-half of one-thousandth of a second in time lag or lead from the standard adopted. Because the ultimate data used in the computations are time determinations secured from seismograms, it is important that amplifiers have a minimum variation in phase from one to another. A phase difference which causes a time lag of 0.001 second introduces an error of approximately four to eight feet in depth and an even more appreciable error in dip computations.

At 50 cps the time of one cycle is 20 milliseconds, so that a deviation of one-half millisecond represents nine degrees maximum tolerance in phase shift at that frequency. Below 50 cps the phase-shift tolerance is even less. Customary laboratory practice is to align amplifiers for phase and amplitude by comparing each channel to the standard with a common signal input and each output connected to a different set of oscilloscope plates. The degree of opening of the resultant ellipse, and its slope, is a measure of the phase and amplitude variations, respectively, between the two chan-



the percussion wave at the stations in the field spread. Later, reflections from different strata arrive at the stations

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nels. In the final overall test the galvanometer camera is used for a simultaneous check on all channels.

Seismic Recording Practice

A commonly used procedure in seismic recording is to add a part of the voltage from one seismometer group to the next adjacent group in a specified direction of the spread. This process is referred to as overlap or compounding, and is used for the purpose of improving the record by accentuating the appearance of the reflected waves against the random noise background.

A commonly used method of electronic overlap is shown in Fig. 7. When the relay contacts are in the right-hand position, each channel except the first one in a group receives some signal from the immediately preceding one, but from no other channel. This is mixed in the common plate circuit with the original signal of the channel itself. When overlap is not desired, the relay contacts are moved to the left and the two sections of the twin triode are in parallel for a single signal source and independent channel operation.

One of the most important elements in a seismic recording truck is the timing system. Without an accurate reliable timing system the records would be useless regardless of their purely seismic quality. All computations of subsurface depths depend on accurate timing. The heart of the timing system is a temperature-compensated tuning fork. It is common practice to use a 100-cycle fork driven by a vacuum tube system. A synchronous timing motor driven by the 100-cycle voltage from the fork oscillator has a disk mounted on it which has slots cut radially. These slots are spaced so that they permit light from a timing lamp to strike the sensitized paper across its full width in a narrow beam every hundredth of a second. One slot out of ten is wider so that a darker line is placed on the paper every tenth of a second. This darker line makes it much easier for the record computer to add the total time from the beginning of the record to a reflecting point.

In addition to knowing the exact time interval between any two timing lines it is also necessary to maintain the recording paper speed constant so that a given time interval on one record will cover the same length of paper as on any other record. This consistancy is essential if any comparison is to be made between records. There are several methods of accomplishing this result. Only one method will be described here because of its electronic interest. It is used chiefly where 100-cycle tuning forks are the standard for timing. Lower-frequency forks can be used but they are bulky.

The electric motor which drives the paper is usually a 6-volt d-c motor because the primary source of power in field recording trucks is a storage battery. In order to run this motor at constant speed a unique method has been developed whereby the speed is electronically controlled by the 100-cycle tuning fork. The d-c motor receives its power as usual from a 6-volt storage battery, but it is mechanically coupled to a small 110-volt, 50-cycle synchronous motor. This a-c motor maintains the d-c motor at the proper synchronous speed although most of the driving power for the d-c motor comes from the storage battery. The additional power necessary to hold the d-c motor to the proper speed is supplied by the 50-cycle synchronous motor.

In a typical installation a 1/100 horsepower synchronous motor controls a 1/30 horsepower d-c motor. The precise 50-cycle power for the synchronous motor is obtained from the 100-cycle tuning fork through an electronic frequency divider which drives a power amplifier. In order to eliminate large power tubes in this amplifier and their heavy drain on storage batteries, the power level is amplified only to the point where it will drive the coil in a tuned mechanical vibrator. This vibrator then supplies the storage battery power in accurate 50-cycle pulses which are stepped up by a transformer and smoothed by a filter before reaching the synchronous motor, as shown by block diagram in Fig. 8.

Communication Circuits

It is important that continuous communication be maintained between the recording truck and the shooting truck. Where the distance between trucks on a spread is less than 2,000 feet it is convenient to use telephone lines. For greater distance, radio communication is used. In addition to voice transmission, provision must also be made for transmission of the time break (instant of explosion) and shot point seismometer first break. The latter gives the time of transmission through the earth from the position of the explosive in the hole to the top of the hole. Figure 9 shows a typical two-way wire telephone system and includes the shot point seismometer and blaster time break amplifier and cutout circuit. It is necessary to cut out automatically all stray signals from the shot point as soon as the time break and shot point seismometer break have been received because these signals are recorded through some of the same galvanometer elements that are being used for seismometer groups on the spread.

In radio transmission where amplitude modulation is used, it is often difficult to pick the exact starting point of the explosion time break because of static and other random noises in the receiver when the signals are weak. The explosion time break is a high-frequency pulse very similar to static. To get around this difficulty, one method used is to modulate the transmitter just prior to the shot with a constant 1,000-cps tone which is cut out at the instant of the explosion. The carrier is left on an additional length of time in order that the shot point seismometer break can also be recorded. In some cases it is not necessary to record the shot point seismometer break, so the explosion time break can be used to cut off the carrier and this event recorded at the receiving point is used as the time break.

Still another method is to start a 1,000-cps modulation on the carrier by means of the explosion and stop the modulation by means of the shot point seismometer pulse arrival. This system is shown in detail in the diagram of Fig. 10 which gives the wiring at the shooting truck. In the bottom center block the left-hand thyratron (type 2050) is fired by the explosion and operates the left-hand relay to connect the 6C8G

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oscillator at the lower right to the triode amplifier in its own envelope. This amplifier feeds the modulator in the transmitter shown in the upper right block. Shortly after the 1000-cps modulation has started, the shot point seismometer voltage amplified by the 6C8G in the lower left fires the right-hand 2050 thyratron. The relay in the thyratron plate circuit grounds the oscillator output.

At the receiving truck the 1000-cps wave train may be recorded in its original form or only the envelope may be recorded. The initiation of the wave train, or leading edge of its envelope, gives the time of the explosion and the trailing edge gives the shot point seismometer arrival time.

In the lower left-hand block is shown a circuit which checks the times as transmitted by radio against the original pulses directly from their source. This record is used only as a check against any possible defects which may arise in process of continued operation. The thyratrons drive the relays so hard that the relay delay is too small to be significant. An ingenious method of transmitting the two timing pulses by means of frequency modulation while reserving amplitude modulation for voice communication is described by Shook, Olson and Kerr in *Proc. I.R.E.* for October, 1944.

Complete Recording Units

The operator's panel is built in a single rack. At the top left is the control panel where all seismometer cables enter, and the signals from the various groups are distributed to the proper amplifier channels. This panel also includes means for testing breaks or shorts to ground in cables or seismometers. At the top center is located the fork oscillator system and telephone amplifier beneath it. On the right is the galvanometer type recording oscillograph, usually referred to as the camera. In the bottom half of the rack there are twenty-four amplifier channels. Each chassis contains two channels. At the left of the channel array are the master switches which enable the operator to select rapidly any desired amplifier characteristics before shooting. Each pair of switches controls its corresponding row of channels. On the right-hand side of the amplifiers are the battery test panels and master firing controls.

This complete system is placed in a truck for use in rough country. These trucks are designed to operate in wooded or swampy sections where they often make their own roads and are able to knock down small trees.

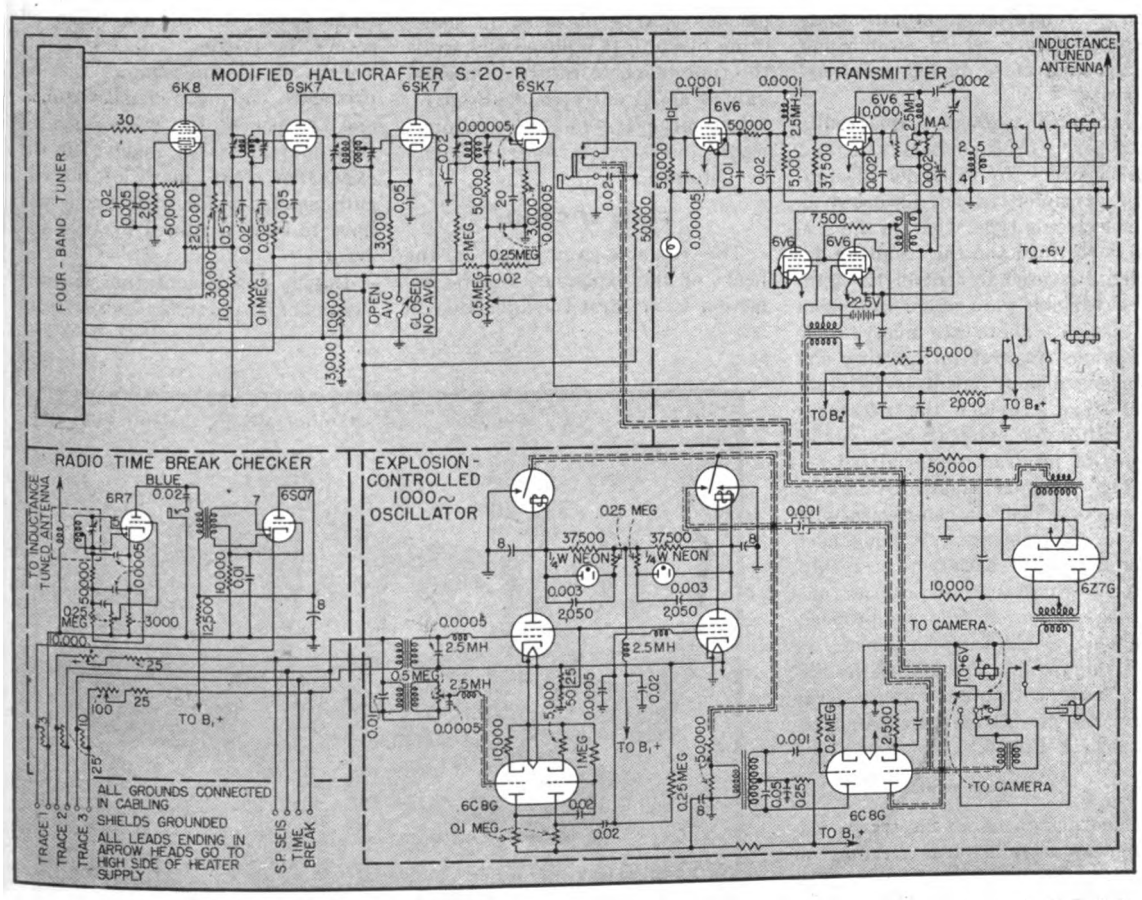

FIG. 10—Communication equipment and keying circuit are used to modulate a carrier from the time the shot is fired until the percussion wave reaches the ground surface above the firing point

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VOLUM

By ROBERT W. EHRLICH
Maplewood, N. J.

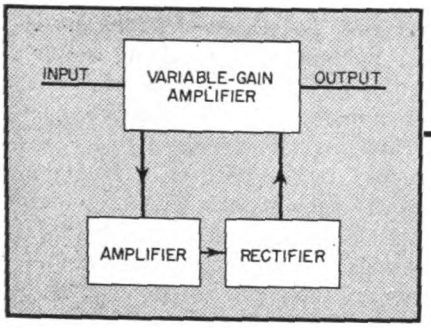

FIG. 1—Block diagram of an electronic volume-expander circuit in which the rectified signal is used to control gain

MANY people, having listened to volume-expansion amplifiers, have found them to introduce undesirable wows, gasps, pops, or just plain distortion in the reproduced output. There is, however, ample justification for volume expansion in the fact that a certain amount of volume compression is used in making a majority of recordings and sometimes in broadcast work. In addition, the reduction of amplification at low levels helps to reduce record scratch and background noise during such passages.

This paper represents the results of a series of experiments to find the answers to expander design. The expander to be discussed is the electronic type, wherein the signal is rectified and the resulting d-c voltage is used to control the gain of a variable-gain stage as shown in Fig. 1. There are many other ingenious ways of introducing volume expansion, but it is felt that this type provides the necessary flexibility for application to varied types of program material.

The expander illustrated in Fig. 2 was developed in connection with these experiments. It has been found to give satisfactory results with a wide range of program material, and, even when improperly adjusted, it does not have many of the undesirable characteristics experienced with other circuits. The complete circuit of the expander is shown in Fig. 3.

Requirements

The design of an electronic volume expander involves a number of interesting problems beyond those ordinarily encountered in amplifier work. The variable-gain stage must operate at not just one point on its characteristic, but rather over the complete range of its characteristics without introducing distortion. The amplifier which feeds the rectifier circuit must have means for adjusting its gain without any audible indication, and this gain must be variable to suit the various input signal levels.

Finally, the rectifier must be capable of rectifying a complex a-c signal without introducing objectionable ripple into the signal circuit. Moreover, the time constants throughout the expander circuit must be so adjusted that full expansion can be obtained in something like 5 to 15 milliseconds, while the time taken to return to normal gain is about one second. By careful attention to all of these requirements, satisfactory operation can be obtained.

Choice of Circuits

The variable-gain stage is the heart of the expander, and its selection is the first consideration in design. Perhaps the most w used tube for this purpose i 6L7, in which the d-c bias vo on grid number 3 controls the of the tube with respect to number 1. Another popular m is to use a variable-mu tube as the 6SK7 and let the [redacted] on the signal grid control t

A less common but very in ious circuit uses a triode tub one leg of a voltage divider for signal. The other leg is a fixed sistor. By varying the bias on triode, the tube assumes diffe values of plate resistance, and there is a variation of the rela signal voltage which is taken across the triode.

Because of the complex bias problems on multi-element tu and because of the wide range tube characteristics involved in expansion stage, many of the cuit constants for that stage have to be determined by trial error.

During experimentation with expansion stage, circuits were

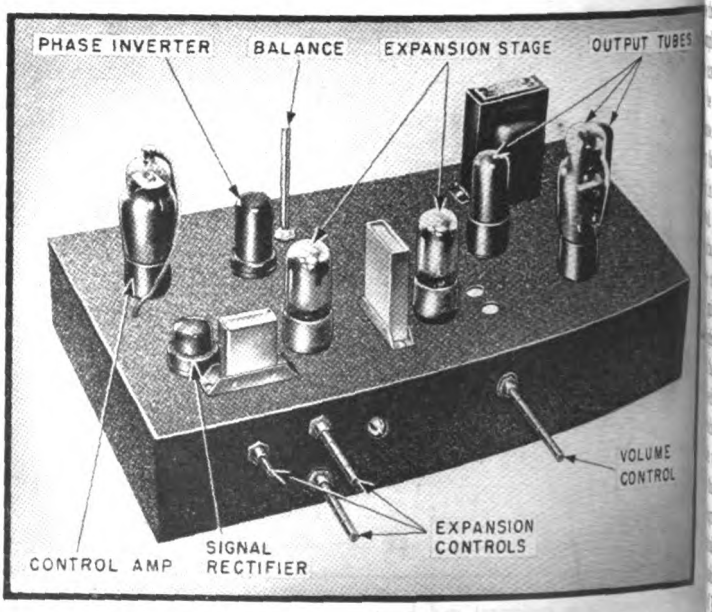

FIG. 2—Chassis of the experimental expansion amplifier

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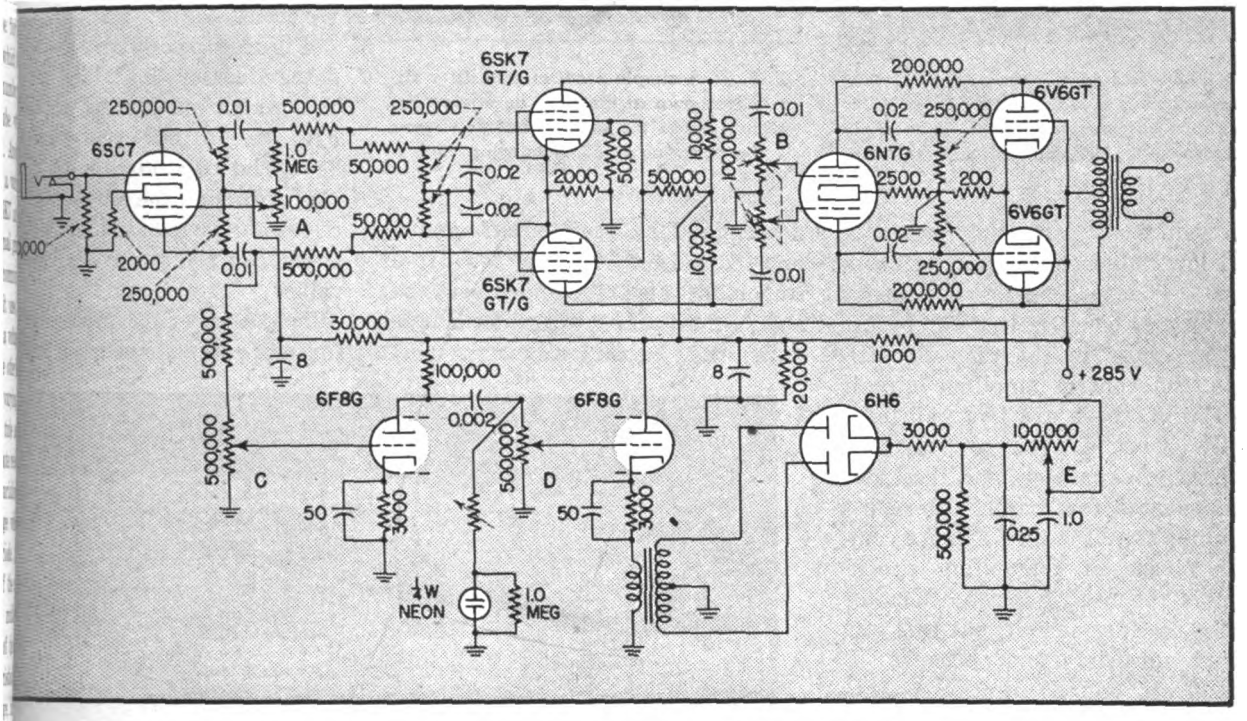
XPANDER DESIGN

ectronic volume expander provides full expansion of a wide range of program ial in about ten milliseconds and return to normal gain in one second. The problems ntered, methods of solution, and results of experimental work are included



3—Final circuit of the expansion amplifier. The lettered controls are identified as follows: *A*-balance; *B*-volume; C-input level; *D*-expansion; *E*-time constant

ed where the input to the con- circuit is taken from the output ie expanding stage rather than input. This type of circuit ld have the advantage of reduc- the amplification necessary to e the control circuit. It was nd to be unsatisfactory, how- r, because of dynamic instability sed by the regenerative action. y delay in expansion was greatly entuated. Moreover, since the trol voltage was proportional to square of the signal input, the ve of gain vs signal was very ep at higher levels. With one cir- t tried, the action of the expander s delayed by one or two seconds, er which the expansion would e place very suddenly. The re- t was that the gain had no rela- n to signal strength with a typ- lly variable input signal.

The push-pull circuit for the ex- nder of Fig. 3 was selected after veral disappointing experiments with single-ended circuits. Not only do the latter have a tendency to distort due to curvature of the tube characteristic, but they also are affected by any residual ripple that may come through from the rectifier. These effects are largely cancelled out in a push-pull stage.

Advantages of Push-pull

Another advantage, though not apparent at first, is the possibility of avoiding the use of bypass capacitors. Changes of screen and cathode voltages in an expanding stage are in such a direction as to oppose the change in gain caused by a change in grid bias. If the cathode or screen voltage variation is retarded by a large bypass capacitor, it is possible for the gain of the stage to increase before this capacitor can change its charge. When it does charge, it pulls the gain down. The result is that the amplifier gain overshoots its final mark and there is a tendency for thumps to be heard in the output. Figure 4 is an oscillogram which illustrates this type of transient response.

Effect of Transients

Another difficulty inherent in single-ended circuits is the possibility of introducing low-frequency transients or thumps in the output, due to rapid expander action. Such transients are cancelled out in a push-pull stage, since the control bias is applied to both grids simultaneously. Even with push-pull operation, however, it is still necessary to keep the transients in the output of the individual expander tubes from becoming so large as to cut off the following stage. This can be accomplished by transformer coupling, a special phase-inverter tube[1], or, as in Fig. 3, through the use of

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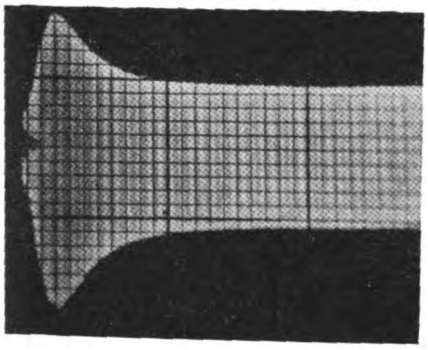

FIG. 4—This oscillogram shows the overshooting of gain caused by a 10-μf cathode bypass capacitor connected across a 10,000-ohm cathode resistor

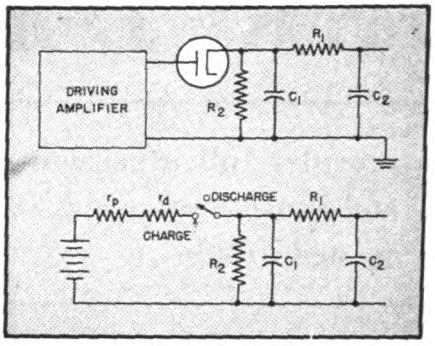

FIG. 5—A simple rectifier and filter circuit is shown at the top. Its equivalent circuit shows the factors that determine the charging and discharging time

low values of plate load resistance and low values of coupling capacitors. The loss in low-frequency response is compensated for by the *RC* networks in the grid circuits.

In the control amplifier circuit of Fig. 3, there are two gain controls. One is used to vary the amount of expansion, and the other compensates for major differences in input signal level. A more common means of controlling expansion is the use of a potentiometer in the rectifier circuit, but this was found unsatisfactory because of its effects on the time constants in the rectifier.

Rectifier Problems

The rectifier with is associated filter is perhaps the most important section of the amplifier, for it is here that the dynamic nature of the entire unit is determined. Improper consideration of these factors can lead to serious volume distortion. The problem is to get an *RC* filter circuit which will react very rapidly to impulses of signal, and still eliminate all traces of rectifier ripple from the signal circuit. The solution is to make all resistors through which the capacitors charge very small, and those through which they discharge very large.

Figure 5 shows the type of rectifier circuit to be considered, along with its equivalent circuit. The charging time is determined principally by the internal impedance of the driving amplifier, r_p, the plate resistance of the diode, r_d and [illegible]; along with capacitors C_1 [illegible] The discharge time is determined by resistors R_1 and R_2 and capacitors C_1 and C_2. It is important also to remember that any other capacitors associated with the expander circuit can affect the time constants.

Calculation of the exact time constants of a circuit such as that of Fig. 5 is rather complex, but the following simple formulas developed by E. W. Kellogg and W. D. Phelps[2] will give the necessary values closely enough.

Charging time constant =

$$(r_p + r_d)\ C_1 + (r_p + r_d + R_1)\ C_2$$

Discharge time constant =

$$R_2\ C_1 + (R_1 + R_2)\ C_2$$

Adjustment of values should be made so that the minimum charging-time constant will not be over 15 or 20 milliseconds and the discharge-time constant not less than 0.5 second. In addition, the total resistance between the control grid and ground should, if possible, be kept below the maximum value specified for the tube us[ed]. The use of a cathode-follower circuit in the driving amplifier circuit of Fig. 3 makes the driver impedance very low and makes it easy to obtain a low charging time. Control of the time constant is obtained by making resistor R_1 in Fig. variable.

Figure 6 shows an oscillogram determination of the minimum charging time for the expander Fig. 3. A 500-cycle signal keyed into the circuit with expansion full on, the 3000-ohm series resistor shorted, and the time-constant control set at its minimum value.

The number of cycles required for 64-percent expansion indicates

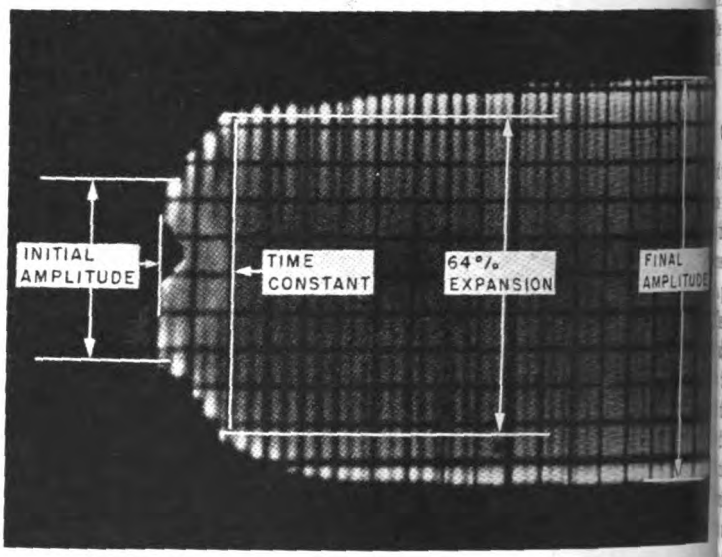

FIG. 6—Oscillogram showing the shortest possible transient response for the circuit of Fig. 3. The notch at the left was caused by masking tape over the stationary spot on the screen

the charging-time constant, eight milliseconds in this case. In practice, the insertion of the 3000-ohm buffer resistor was found valuable in materially reducing rectifier ripple. This resistor brought the time constant up to 12 milliseconds.

Static Test

Performance is determined by testing for change in gain, or expansion, with respect to control voltage. For this test, control voltage is most easily obtained from a battery and potentiometer. A gain curve for the expander is shown in Fig. 7. The points to be noted are first, that the maximum

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in gain without distortion at least about three times , and second, that the curve versus voltage should be straight over the range

mpensate theoretically for al compression character- ll of the expansion would) take place in the upper (20 percent) of the control swing. This characteristic ier necessary nor desirable. e thing, the input level to circuit would be very criti- cessitating many readjust- of input level. Further- this type of curve can lead esirable dynamic character- especially in connection with g time constants. This ation will make the expan- me on suddenly, many milli- after the initial input The effect is difficult to but it is unquestionably nt.

Operation

g of the amount of expan- the time constant is com- by the fact that it is prac- impossible to detect the of a properly adjusted ex- There is a natural ten- o advance the expansion to the point where the of the expander can be or if time and effort have ut into the construction of circuit, one likes to hear it As a matter of fact, the way to tell accurately how well xpander is operating is to play same passage twice, once with nsion on and once with it off. is only possible with phono- h records, for which reason rds are probably the best rce of program material for one is learning to use an expander. nce some experience has been ned with the expander, the two n controls *C* and *D*, and the neon licator in Fig. 3 can be used to vantage in setting up the ex- nder for operation with any type signal. The resistors associated th the neon lamp are so adjusted at the lamp begins to glow when signal voltage is large enough drive the expander to full ex- nsion. The level at this point is justed by control *C* in such a way that the lamp will blink at peaks of modulation. For any radio station or record, this adjustment can usually be made in a few seconds, and it will hold as long as the same input source is maintained. With the signal level in the expansion control circuit so adjusted, it is then possible to set the second gain control, *D*, in terms of its own panel calibrations to give the number of decibels expansion desired for the particular program material.

Typical Control Settings

Actual settings of the expansion and time-constant controls will naturally vary for different types of program material. Symphonic selections are perhaps easiest to expand. This type of music will take all the expansion the amplifier can give, at the shortest time constant, without any unpleasant reaction. The only limit here is the point where soft passages are too soft to hear and loud ones uncomfortably loud. Martial band music also falls into this category.

Dance music is a little more difficult to handle, and expansion should be used cautiously. The time constant should be short when the music is slow; but if the music is fast and hot, a long time constant is required to swamp out the rapid volume impulses and prevent jerkiness.

Speech is also difficult to handle but expansion can still be used to advantage if it is used sparingly. Time constants on speech should be kept short to preserve the natural expression. An over-long time constant and excessive expansion can lead to a very undesirable gasping or breathless effect.

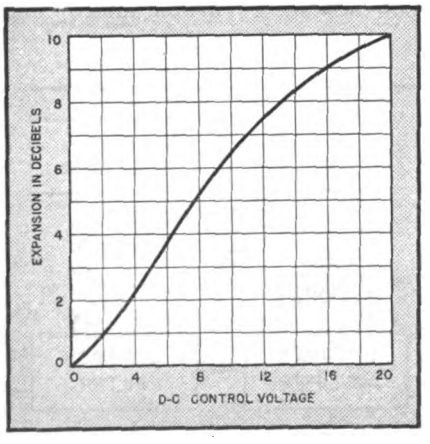

FIG. 7—Static gain versus control-voltage characteristic of the push-pull expansion stage shown in Fig. 3

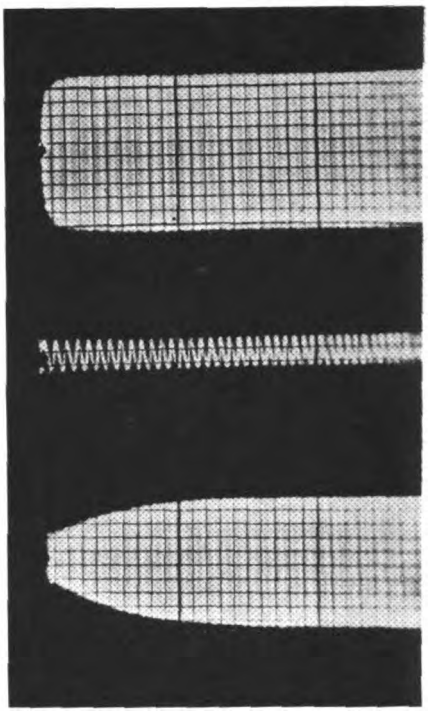

FIG. 8—Variation in charging-time constant available with the circuit of Fig. 3. Minimum is shown at the top of the illustration, and maximum at the bottom. In the center, a 60-cycle trace is given for reference

TABLE I. RECOMMENDED EXPANDER SETTINGS

Program Material	Expansion	Time Constant
Symphonic Music, Band Music	Full	Short
Dance Music (slow)	Medium	Short
Organ Music	Low	Short
Speech, Dance Vocals	Low	Short
Swing Music (fast)	Medium	Long
Operatic Vocal Solos, Instrumental Solos	Not Recommended	

One type of material for which expansion is not recommended is a vocal or instrumental solo. The performer puts in his own volume expression, and expansion will seriously distort it. The effect is at its worst when the expansion control circuit has peaks in its frequency response so that certain notes are expanded out of proportion to the rest.

Table I indicates in convenient form the expander settings recommended for various types of material.

References

(1) Weidemann, Lt. Henry K., USNR, A Volume Expander for Audio Amplifiers, *QST*, p 19, Aug. 1945.
(2) Kellogg, E. W., and Phelps, W. D., Time Delay in Resistance-Capacity Circuits, ELECTRONICS, p 22, Feb. 1937.

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CRYSTAL-DRIVE
for D-C Amplifie

A 1000-cycle signal actuates a rochelle-salt crystal that drives a carbon button in series with the d-c signal to be amplified. The composite signal is amplified and demodulated at high level

By JAMES A. WILLIAMS
Naval Ordnance Laboratory
Washington, D. C.

OF the many problems encountered in the design of a sensitive d-c amplifier, one of the most troublesome is that of drift of the zero-signal point due to unavoidable changes in supply voltages, circuit constants and tube characteristics. One solution is to impress the d-c signal on a high-frequency a-c signal in such a manner that the resultant amplitude of the combination signal is proportional to the instantaneous value of the incoming d-c signal. The modulated signal is then amplified and rectified at high level to obtain a d-c voltage or current proportional to the original d-c signal.

One method of applying this principle of operation involves the use of a mechanical chopper which periodically interrupts the d-c signal and applies the resulting a-c signal to the input of a conventional a-c amplifier. The principal limitation of this method is that the highest frequency component of the signal to be amplified must be low compared to the chopper frequency. This is sometimes difficult to achieve because of the upper freqency limit of the vibrating or rotating mechanical system due to mass, stiffness and other factors. Moreover, considerable hash is caused by the making and breaking of the contacts and this limits the lower range of signals to be amplified.

Construction of Driver

The device to be described is in effect a chopper which is less subject to the above mentioned limitations than the conventional discontinuous mechanical device. It consists of a carbon microphone button mechanically coupl rochelle-salt crystal. The of coupling and mechanical are shown in Fig. 1. The unit is supplied excitation oscillator operating at a fre of 1000 cycles. It is essenti the output of the oscillator constant. This condition tained by the use of a thre tungsten lamp in the cath the first stage of the oscillato

The d-c signal to be ampli applied to the input transf through the carbon butto shown in Fig. 2. Conversion d-c input to an a-c signal i complished by the carbon b due to the continuous vibr of the rochelle-salt crystal which the button is mechani coupled. This action results loss in signal of about 3 to 1 tween the d-c input and the mary of the input transformer. step-up ratio in the transforme about 30 to 1 compensates for loss and results in an overall of approximately 10 to 1 betw the d-c input terminals and grid of the first tube.

Calibration

To permit accurate measurem of the d-c signal, means is provi for calibration of the system the introduction of an accurate known calibrating potential.

As shown in Fig. 3, the calibr tion system consists of a ladd

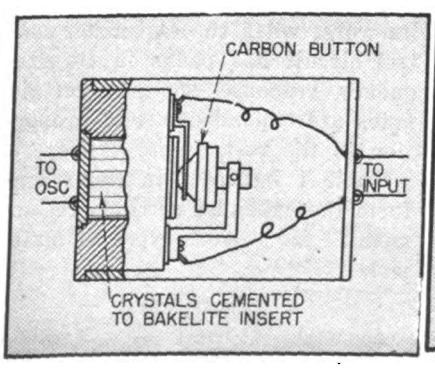

FIG Mechanical details of the driver assembly

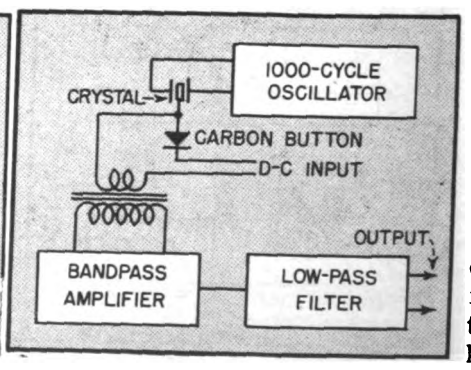

FIG. 2—The essential units of the system

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RODULATOR

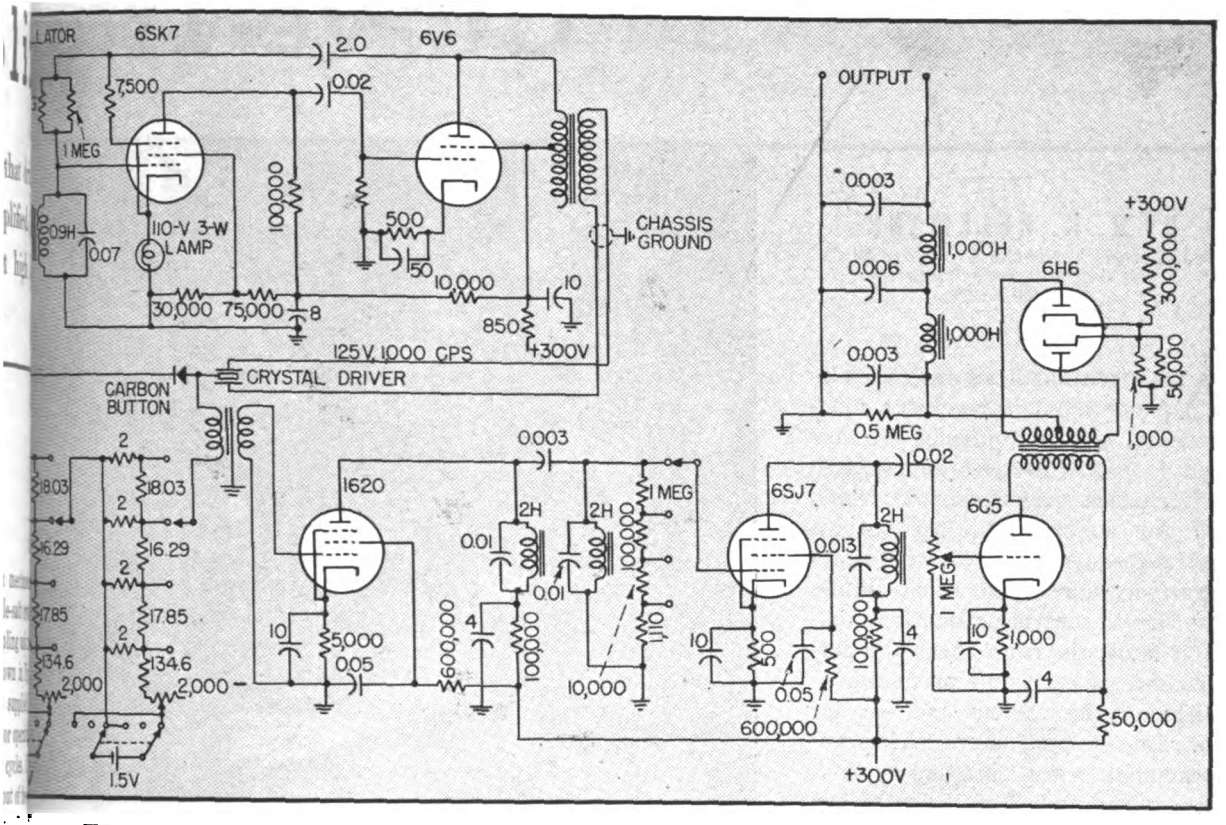

FIG. 3—The circuit shown above provides a d-c output of 40 volts with an input of 20 microvolts

supplied by a 1.5-volt bat-
ith a switch for reversing
arity. The calibrating volt-
pears across a 2-ohm resist-
l series with the input and
inuously adjustable over the
range of the amplifier. A
ste calibration system may
d as shown to balance out
eady d-c potential that may
sent in the input.

a-c signal resulting from the
of the converter is amplified
three-stage bandpass ampli-
The response of the amplifier
is flat within ±0.5 db from
) 1100 cycles, making possible
vation or recording of signals
0 to 100 cycles. This pass
might be extended if a higher
ency response were desired.
carrier signal is effectively
inated by a low-pass filter hav-
a cutoff freqency of 150 cycles,
an attenuation of 70 db at 1000
es. The output filter operates
a 500,000-ohm load.

he input impedance of the de-
is limited by the carbon button
around 75 ohms. This imped-

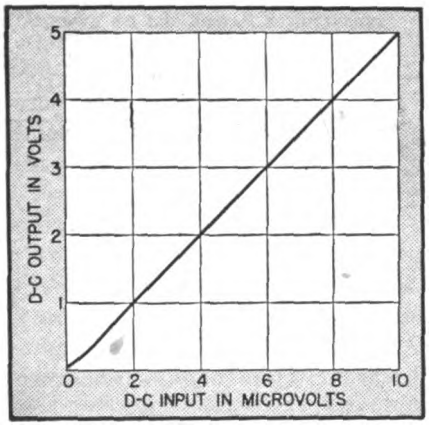

FIG. 4—The calibration voltage was used as the input signal to obtain this curve

ance might be increased by adding series resistance, with a consequent loss in voltage sensitivity. A gain control and step attenuator are included in the amplifier, to provide for a wide range of input levels.

Output Voltage

In Fig. 4 is shown a linearity curve of the over-all system. This curve was obtained by using the calibration voltage as the input signal and reading the output voltage on a high-impedance d-c meter. The attenuator was turned to the maximum sensitivity position and the gain control adjusted to give 5 volts output with an input of 10 microvolts as read on the dial of the calibration system. The curve was repeated on each scale with results that deviated only about three percent. The maximum output voltage obtainable is 40 volts with an input of 20 microvolts. This makes it possible to calibrate the system at any convenient output voltage up to this value.

The instrument was used satisfactorily in making field measurements of signals ranging in level from 2 microvolts to 30 millivolts and varying in frequency from 0 to 100 cycles. No zero shift was observed.

For use on the high-sensitivity range, it was found necessary that the input tube and the crystal driver be properly cushioned to prevent microphonics and that adequate shielding be employed.

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Curve-Tracer

By R. K. HELLMANN

Connecticut Telephone & Electric Div.
Great American Industries, Inc.
Meriden, Conn.

ACOUSTICAL DEVICES such as telephone handset receivers, loudspeakers, and microphones are now manufactured in accordance with performance specifications which call for a predetermined output-versus-frequency curve with comparatively narrow tolerance limits. In order to control production quality it is necessary to check the performance of each unit produced.

Among the various methods of recording a test curve the semi-permanent trace obtained with a cathode-ray tube of long screen persistence was found the most practical solution. A curve traced in this manner with a relatively slow sweep can be made visible between 3 and 15 seconds, which is long enough to produce the impression of the complete diagram, and short enough to cause no interference with a subsequent curve.

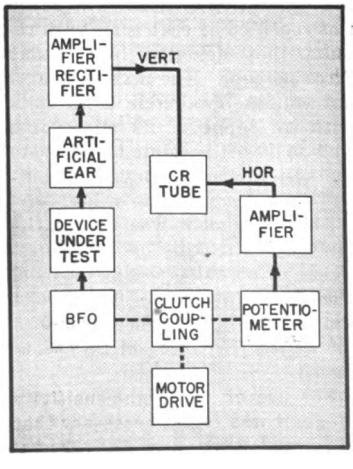
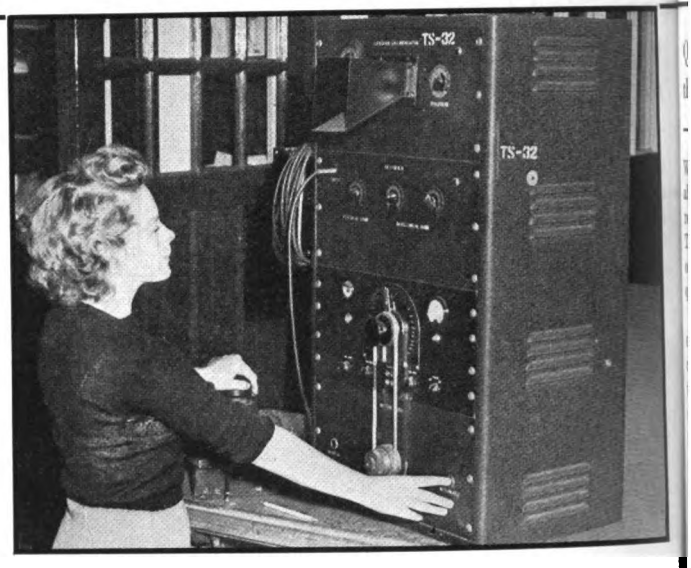


FIG. 1—Curve tracer includes these units. Artificial ear is a crystal or capacitor microphone



With her left hand the operator holds a handset receiver which is being production tested for frequency response. The belt, center, drives the bfo and synchronizes it with the c-r sweep. Trace appears at top, inside light shield

The curve tracer described here is based on this recording principle. A study of the literature reveals considerable previous work in this direction, largely with the view of producing diagrams automatically by means of advanced electronic arrangements, whereas in the present instrument straightforward circuits and methods are used. However, the fact that in its present form it has withstood the rough treatment on the assembly line over a period of five years while testing well over a million units justifies this report.

Operation of the curve tracer is shown in the block diagram in Fig. 1. The device under test is fed from a beat-frequency oscillator whose frequency is varied by a mechanical drive. The same drive also actuates a potentiometer which controls the horizontal deflection of the luminous spot in the cathode-ray tube. The device under test may be, for instance, a handset receiver. It is coupled to an artificial ear. The output of the latter is amplified, rectified, and applied to the vertical deflection plates of the oscilloscope.

Frequency Sweep

The mechanical drive affords automatic scanning and consists of a reversible a-c motor with double gear reduction. On the slow shaft is a coupling device which, in the engaged position, connects the motor drive by means of a pretensioned metal belt with the pulley on the beat-frequency oscillator. Also on the slow shaft is a cam which operates two adjustable sets of contacts.

Figure 2 illustrates the operation of the drive circuit. When the starting button is pressed, the armature of the motor is energized through the contacts of the holding relay so the motor moves forward, starting the frequency sweep.

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for ACOUSTIC DEVICES

Quality control over full-scale production output of handset receivers is obtained through the use of a powered-sweep bfo, a long persistence c-r tube, and suitable test fixtures

When the cam opens the adjustable end contact, the holding relay releases and reverses the motor. This moves the beat-frequency oscillator toward its starting frequency.

Near the rest position, a cam-operated switch opens the armature circuit and stops the motor. If the inertia of the armature should carry the cam beyond the range of this rest position a second contact on the same adjustable arm closes and makes the motor rotate in a forward direction until it comes to rest between the two contacts.

When the end contact in the forward direction opens, a quick-acting relay lifts the bias of the cathode-ray tube. The bias is normally sufficiently negative to blank out the beam. In this manner a trace is produced on the screen only during the forward sweep. Since current density in the spot and accelerating voltage are high to make the afterglow of the trace last a long time, this precaution is necessary to prevent burning of the screen with a stationary spot.

Provisions are made to operate the drive and the frequency-determining potentiometer by hand so details of the diagram can be retraced. To this end the coupling device on the slow motor shaft can be pressed inward to disengage the metal belt from the shaft of the drive and the associated cam. However, engagement with the potentiometer which controls the horizontal beam displacement is retained. When released, an arrangement of spring pins relocates the oscillator control at the starting frequency as determined by the adjustable contact arm.

Since manual operation does not energize the holding relay the cut-off bias must be lifted in that case by pressing a button marked 'Manual'.

Potentials at both ends of the sweep potentiometer can be adjusted by two separate controls so the frequency range of the sweep, as set by the adjustable cam contacts, can be spread out to any desired length on the screen.

Test Fixtures and Circuits

It will be realized that the curve tracer as a production testing device is only as practical as the auxiliary apparatus and fixtures.

Figure 3 shows the test fixture and circuit of a handset receiver. Since the cavities in the molded cap of the handset establish the shape of certain parts of the response curve, the test fixture consists of a handset with a special cap that is quickly detachable by means of a bayonet lock. A spring holds the unit against the coupler of the artificial ear with the prescribed pressure of 1 kilogram and also holds it safely in the loading position. The receiver under test is connected to the low-impedance output of the beat-frequency oscillator through a resistance equal to the nominal receiver impedance at 1000 cycles, and the voltage is adjusted at the same frequency so 1 mw is delivered to the receiver.

A crystal microphone made by Ballantine Laboratories and equipped with a coupler of approximately 12 cu cm has been found highly suitable for this application.

In order to stabilize the receivers magnetically a cam transfers the receiver leads momentarily to the source of stabilizing current during the closing of the handset arm in the fixture and restores them to the audio voltage just before the receiver seats itself on the coupler.

A somewhat more elaborate fixture is illustrated in Fig. 4. It accommodates the two receivers of a headset and is therefore equipped with two artificial ears. These are mounted on a support plate which can be lowered by a foot lever for

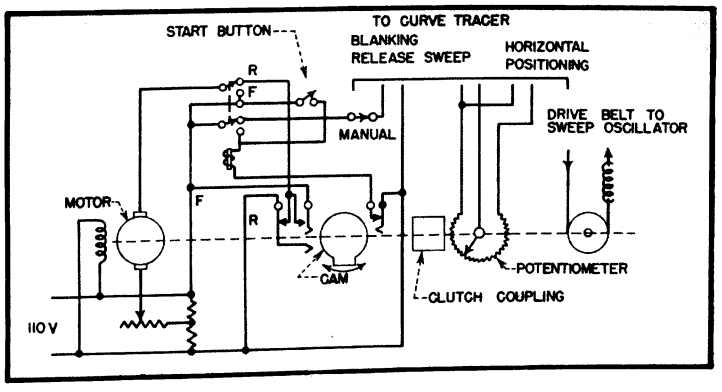

FIG. 2—Details of drive circuit. Cam and contact arrangement establishes start and stop positioning of mechanical train

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loading. The receivers are placed in positioning recesses in the loading platform. When the pedal is released the ears are lifted by a spring which presses their couplers against the receiver units and the individual loading weights.

When used for testing high-impedance headsets of the resonant type, this fixture is associated with the circuit shown in Fig. 5. This was developed in accordance with the observation that sufficiently informative curve-tracer diagrams are obtained if both receivers, coupled to their respective ear cavities and connected in series, are run together. The output of each ear can be connected to the curve tracer input by means of switch T.

The data to be checked are the frequency and amplitude of the resonance peak, its width at 6 db down, and the impedance at peak output. Measuring the latter is at the same time an insurance that the output measurement in series connection does not introduce errors due to uneven voltage distribution. The test circuit can accordingly be arranged to provide four conditions which are selected by means of a 3-deck, 4-position switch, *S*.

After placing the headset in the fixture the operator proceeds as follows: position 1 of the main switch S is a calibrating position. Voltage E_1 is adjusted at 1000 cycles to a standardized value, and a fixed small fraction is fed directly into the curve tracer input whose gain is then adjusted against a calibrating mark on the screen.

In position 2, one-half of the standardized input is fed to the two receivers in series and the resonance peak is noted. Immediately, the curve is repeated with full input voltage in position 3. The location and magnitude of the main resonance can be noted as well as its width at a level 6 db below the peak, which will still be visible faintly from the trace taken in position 2.

By switching *S* to position 4 a comparatively small measuring resistance *R* is inserted into the circuit and the potential drop across it connected into the curve-tracer input. The resulting curve represents E_1R/Z and can, as *R* and E_1 are constant, be interpreted in terms of *Z* as a function of frequency. It is particularly convenient to read impedance at the output peak frequency, which has been set as a specification requirement.

When it comes to testing high-fidelity receiver units whose output level must be kept within narrow limits and is to be determined in terms of absolute sound pressure, the crystal microphone is no longer used.

Figure 6 shows a production line fixture using a Western Electric 640-A capacitor transmitter with a 6-cu-cm coupler, preamplifier and power supply.

The fixture is combined with a demagnetizer which reduces the initially fully-charged receiver magnet to a value indicated by the curve-tracer diagram.

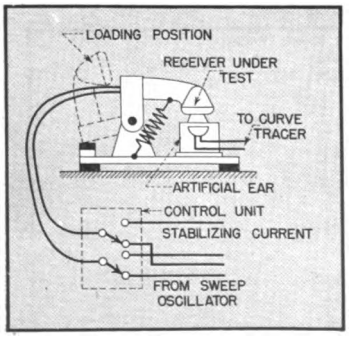

FIG. 3—Production test fixture duplicates physical arrangement of actual handset receiver

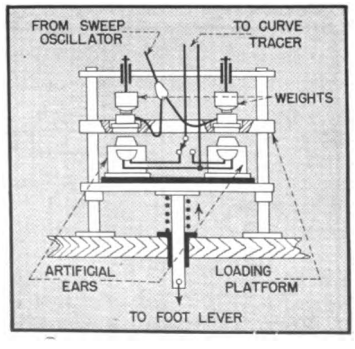

FIG. 4—Duplex fixture tests two receivers of a headset at once. Circuit is shown in Fig. 5

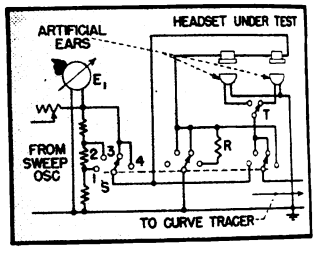

FIG. 5—Headset receivers are tested in series using the production fixture of Fig. 4. Individual outputs are connected to the curve tracer by switch T

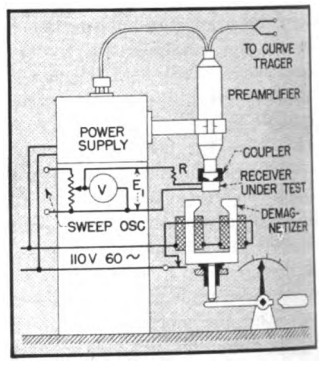

FIG. 6—High-fidelity receiver-units with narrow limits are tested in this fixture which combines a capacitor microphone and hand-actuated demagnetizer

The U-shaped laminated yoke of the demagnetizer is excited with 60-cycle a-c and can be lifted by means of a hand lever to expose the receiver magnet to a stronger or weaker alternating field. In the lowest position the exciting winding is disconnected.

For use with this fixture the standard curve tracer was modified slightly. The bias of the cathode-ray tube was adjusted so that a faint spot was normally visible instead of completely cut-off. The clutch mechanism was provided with a detent at the 1000-cycle point in the disengaged (manual) condition.

With this arrangement the first test operation is to set the sweep frequency by hand to 1000 cycles and adjust the input voltage E_1 so that the light pointer hits the zero-db level marked on the screen (see also Fig. 7B). The calibrated voltmeter will then indicate, in db above a reference level, the sound

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pressure developed by the receiver under test. By gradual demagnetization, response can be brought between limits marked on the voltmeter dial.

The clutch is subsequently reengaged to the lower starting frequency and the sweep with a brilliant trace is initiated by pressing the starting button. The curve will, of course, go through zero at 1000 cycles and therefore represent deviation from that point.

Screen Markings

To facilitate rapid interpretation of the diagrams produced by the curve tracer, the screen markings deserve special attention. Figure 7 illustrates three types of markings used.

Lines and symbols are usually drawn directly on the outside of the screen. The choice of a particular marking scheme depends, of course, largely on the test specifications. In Fig. 7A for example, which shows the pattern obtained with the fixture of Fig. 3, it was possible to describe the tolerances of the output curve simply by an upper and lower limit. The shaded areas were painted red so parts of the ordinarily bluish-green trace changed to that color as soon as they exceeded the permissible limits. It would be conceivable to utilize this for an automatic rejection feature by placing in front of the screen a phototube which has been made selectively responsive to red by suitable filters.

The two dashed frequency lines serve as calibration points for frequency adjustment, and the horizontal markings serve for gain adjustment by means of a standard unit.

In Fig. 7B, the curve will always go through the intersection of the 1000-cycle line and a zero-db horizontal. Again a number of calibration markers can be seen. Due to higher accuracy required with this test, the width of the trace had to be considered. Unless push-pull deflection amplifiers are used, the diameter of the luminous spot is likely to vary from one end of the curve to the other. If this is the case, the lines denoting the limits should be corrected so that the interference between any part of the spot and the limit line is not acceptable. To use for this purpose the imaginary center of the spot was generally found unsatisfactory in practice.

In Fig. 7C still another method of marking is indicated. A number of taut black wires are placed across the screen to denote such values as minimum amplitude and frequency limits. This method is particularly convenient for small production runs.

Interpretation

Referring to Fig. 7, a few typical clues to production faults as indicated by the curve tracer can be seen. In the high-fidelity receivers, Fig. 7A and 7B, the slight hump at about 2000 cycles is controlled by an acoustical coupling resistance which connects two cavities inside the receiver.

If this resistance is produced by a piece of silk, its porosity must be kept in a prescribed relation to the volume of these cavities to produce a flat response curve. Too little porosity will result in a pronounced peak in the curve, too much, in a dip. If the silk breather has come loose, this is usually revealed by a rake near the top of the hump.

The peak near the high frequency end is caused by acoustical cavities between the diaphragm and the earpiece of the receiver. In this space a moisture guard in the form of a thin diaphragm is usually placed. Slackness of this membrane may modify the shape of this peak considerably and it is therefore important to control its tension carefully. The shape of output curve in this region reveals to the skilled operator the nature of the required correction.

In the response curve shown in Fig. 7C the location and height of the resonance peak is influenced largely by the condition of the magnetic diaphragm. One of the common faults indicated by a shift in the resonance peak is distortion of the seating surface caused by insufficient lapping or faulty clamping. The degree of sag due to magnetic attraction determines the effective air gap of the receiver and is therefore revealed in both the output and impedance curves. Likewise the degree of magnetization can be determined.

Obviously there are many problems in quality control of acoustical devices where testing by the curve tracer can be applied advantageously. These include production testing of loudspeakers and radio receivers. For testing the latter, the sweep frequency generator can be used to modulate the signal generator, and the demodulated signal as picked off the voice coil of the receiver under test could be used for vertical deflection. Such a test would take only a few seconds but might present a better picture of the audio performance of a receiver than methods presently used.

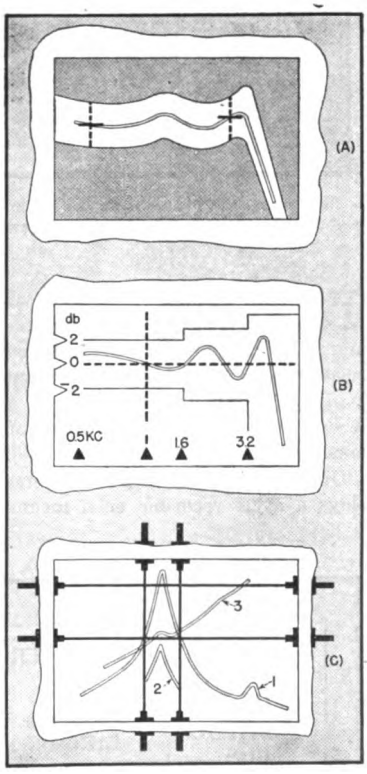

FIG. 7—Three alternative types of screen markings for production-line evaluation of curve-tracer readings. Pattern at A has shaded area painted red to show plainly any deviation of the trace from established limits. Marking B has limit lines established for contact with peaks in curve. Taut black limit wires are used at C for ease of changing on short runs

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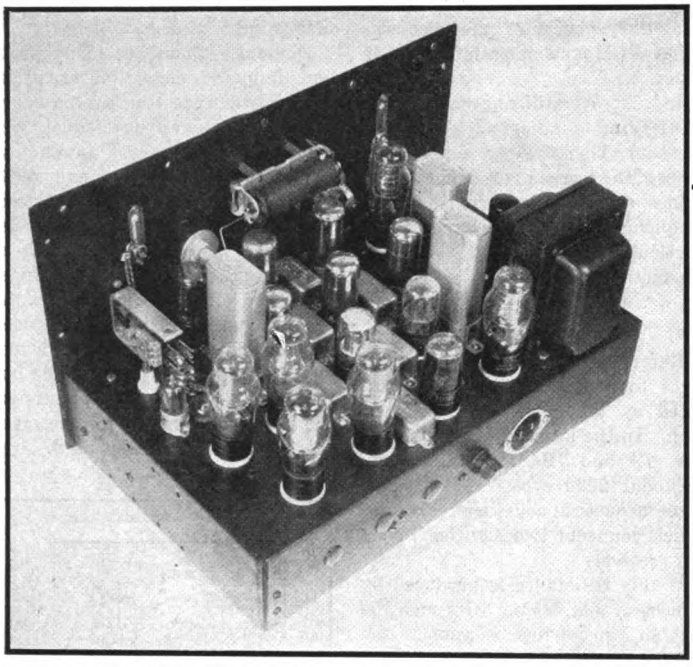
Machine Gun

By ARVID D. PETERSON
Radio Engineer
Naval Air Station
San Diego, California



Rear view of indicator, designed for operation from 115-volt, 60-cps power. Overload relay operates if gun stops before firing the full 17 rounds required to shut off the timer

THE testing and qualifying of machine guns requires checking as to rate of fire. Since these measurements must be made from a single burst which lasts but a second or two, ordinary methods of measurement are not adaptable.

One system used in practice employs a cycle recorder as a means of comparing the time duration of about 20 rounds with a time base (usually the 60-cycle line frequency), the rate being calculated from the tape.

The rate-of-fire indicator here described was developed to fill the need for an instrument which could be more conveniently used where testing operations require a large number of measurements to be made rapidly. The instrument is of radically new design, is direct-reading from 600 to 900 rounds per minute, and operates from the 60-cycle a-c line.

Circuit Principles

The instrument consists essentially of an electronic counter, timer, gate circuit, vacuum-tube voltmeter, calibrator, and voltage-regulated power supply, arranged according to the block diagram in Fig. 1.

The mechanical switch unit is clamped to the top cover, directly over the belt-feed slide assembly of a .50 calibre machine gun. The reciprocating action of the slide mechanism actuates a Micro-Switch to initiate generation of a saw-tooth voltage pulse each time a round of ammunition is fired. Firing of the gun thus generates a series of periodic saw-tooth wave forms. These are differentiated

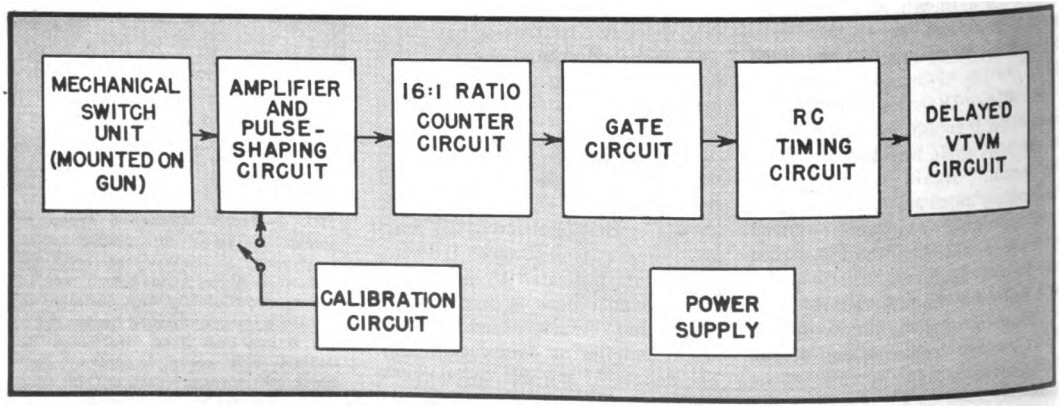


FIG. 1—Block diagram of machine gun rate-of-fire indicator

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Rate-of-Fire Indicator

Electrical impulses initiated by a mechanical switch are counted and timed by a series of five Eccles-Jordan trigger circuits and the rounds per minute indicated directly by a vtvm. Non-military production uses are indicated

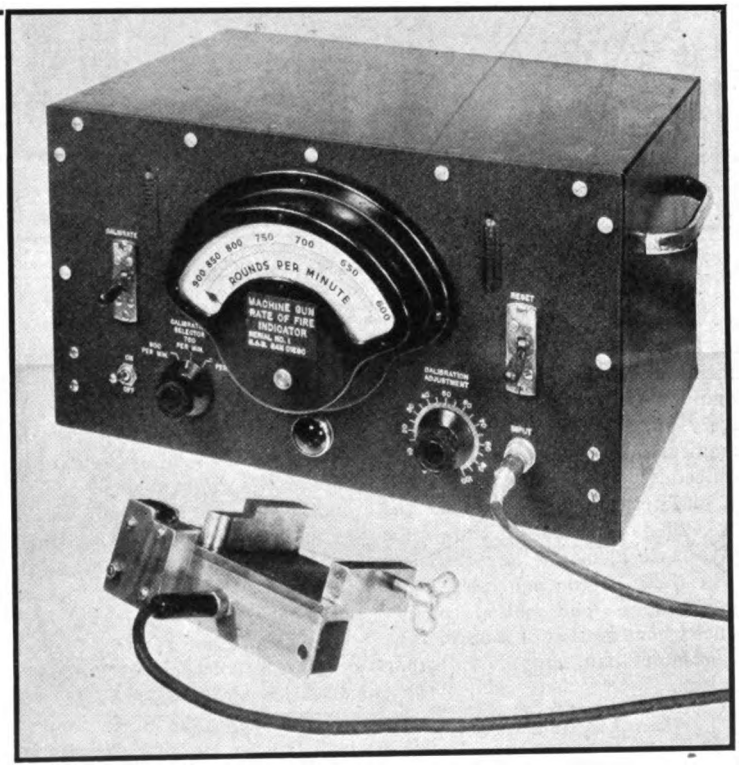
into negative pulses of short duration and impressed on the grid of the input amplifier to be limited to the proper amplitude for the triggering of the counter circuit.

The timing circuit is controlled by the counter and its associated gate circuit in such a manner as to start and stop the timing action of the timer according to the time required to fire 17 rounds. This time interval is thus a direct measure of the rate of fire. A timing capacitor is charged for the exact duration of the counting period, and the resulting potential of the capacitor is a function of the charging time. This potential is measured by a delayed vacuum-tube voltmeter which is calibrated to read in rounds per minute.

Counter Circuit

Since the primary requisite of the counter circuit is to control the timing period of the timer according to the rate of fire, the counter cannot introduce any time error. This is not true with simple counter circuits based on the accumulation principle, where the occurrence of each pulse causes a capacitor to charge step by step until a predetermined potential is reached which permits a trigger tube to respond. Since the grid potential at which a trigger tube responds is never exactly constant, a time error results, as illustrated in Fig. 2.

Due to the resistance of the driving circuit, the voltage of a capacitor cannot be changed instantly. Therefore, the leading edges of the steps are not sufficiently steep to reduce error to within an allowable tolerance. For this reason, counter circuits based on the trigger principle were used. A series of five Eccles-Jordan trigger circuits provides a counting ratio of 16 to 1.



Front view of machine gun rate-of-fire indicator, with mechanical switch that clamps on gun and closes a circuit once for each round of ammunition fired

The operation depends upon each stage having two conditions of stable equilibrium. Every impulse impressed on the input circuit causes a transition from one state of equilibrium to the other, two impulses being required to complete one cycle. Each stage following the first receives a negative triggering impulse upon every alternate operation of the preceding stage. Hence, the fifth trigger stage, which functions to control the gate circuit, remains in one state of equilibrium for the exact duration between the first and seventeenth rounds, or 16 intervals.

Any number of rounds between 17 and 32 can be fired but only the first 17 are counted and timed. A reset switch is provided for the purpose of restoring each trigger circuit to its initial state of equilibrium, and also to discharge the timing capacitor in preparation for a firing test.

Two neon lamps on the front panel (see photos) are connected to the first and last counter stages, and serve as an added check on the operation of the instrument. The lamp at the right should ignite on

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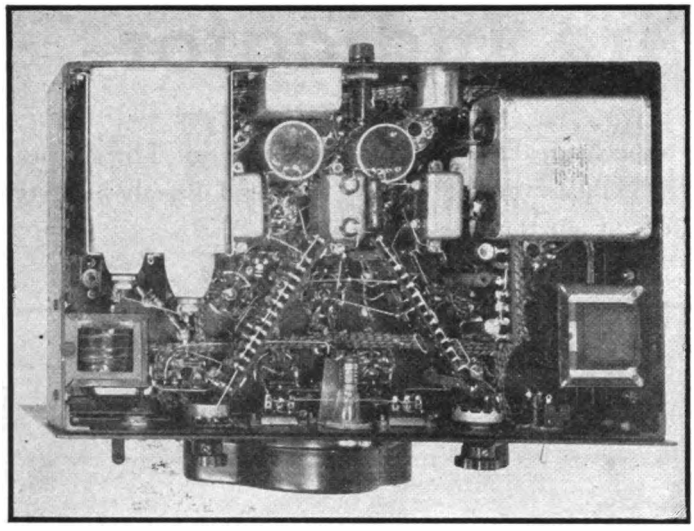

Under-chassis view of machine gun rate-of-fire indicator

the first impulse and not extinguish until the 17th impulse, while the lamp on the left should glow on every other impulse from the mechanical switch.

Loctal type 7N7 tubes were used in the trigger circuits since the two triode sections of this tube have more identical characteristics than those of the equivalent type 6SN7 tubes. The mutual conductance of one section of a 6SN7 tube is greater than that of the other section.

Timer and Gate Circuits

Most electronic switching arrangements which suggest themselves are not suitable for use with a delayed-bias vacuum-tube voltmeter, since the timing capacitor must charge from zero or its initial potential to a more positive potential so as to exceed the cutoff bias of the vacuum-tube voltmeter. If a vacuum tube had been used as the switching mechanism, a timing capacitor in the cathode circuit would have been required to obtain a positive rising potential. Such an arrangement results in undesirable leakage resistance between cathode and filament of the tube, or between the filament winding of a transformer and ground, as the case may be.

These problems and the accuracy required imposed special considerations for the electronic switching and timing circuits, resulting in the development of the design shown by the schematic circuit in Fig. 3. In principle, the zero bias voltage on the grid of the gate tube causes the tube normally to conduct, and the current flowing through the plate load resistor results in a plate voltage of less than the igniting potential of the neon switch lamp. The potential of the timing capacitor is zero, it having been fully discharged during the operation of the reset switch.

Upon firing the first round, the final trigger circuit shifts its state of equilibrium, initiating a negative gate pulse which drives the gate tube far beyond cutoff. Since the *RC* time constant of the input circuit is longer than any interval to be measured, the grid remains cut off until the end of the gate pulse.

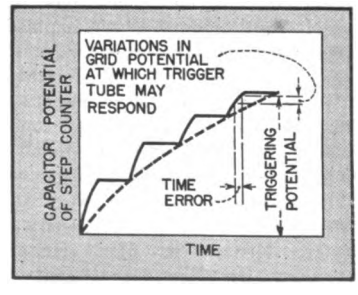

FIG. 2—Characteristics of a conventional step counter, illustrating time error

Thus, the gate tube has an output pulse with an amplitude exactly that of the regulated power supply, as shown in Fig. 4. This voltage is applied to the neon switch-lamp, causing it to ignite and start the charging of the timing capacitor. The voltage of the capacitor increases exponentially at a rate determined by the *RC* time constant.

After the 17th round has been fired, the final trigger stage reinverts to its initial state of equilibrium and a positive pulse is suddenly applied to the grid of the gate tube. This reduces the plate voltage to a value below that of the extinguishing potential of the neon switch-lamp and cuts off the *RC* timing circuit, leaving the capacitor with a definite charge.

By this time, the timing capacitor has charged to a potential more positive than the plate voltage of the conducting gate tube, resulting in a sudden reversal of voltage across the neon switch-lamp as it extinguishes. This reduces the deionization time and the error which would result from an inconsistent deionization time.

After the circuit through the neon switch-lamp has been cut off, the timing capacitor should retain its charge over a reasonable period of time, to prevent the meter reading from drifting. The extent to which this can be accomplished depends upon the leakage of the capacitor itself and its associated circuit elements.

Leakage currents were minimized by removing the base from the neon switch-lamp, replacing insulation of the reset switch with polystyrene, designing the vtvm to have high input resistance, and using a special timing capacitor having very high leakage resistance. Oil-impregnated capacitors are now available with leakage resistance in the order of 20,000 megohms per microfarad. Such a long *RC* time constant makes possible the holding of the charge on the capacitor without loss of more than one percent in over three minutes.

The main consideration in the vtvm design was to obtain a high input resistance and a high degree of accuracy.

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A type 6C4 miniature tube was used because its electrodes pass directly through the glass, greatly increasing the insulation resistance as compared with ordinary tubes. Some input conductance also results from initial electron velocities emitted by the cathode. This was reduced by operating the heater of the vtvm at reduced voltage.

Filament voltage regulation of the vtvm was found to be advantageous in maintaining meter calibration independent of line voltage fluctuations, especially when operating the heater at reduced temperature.

Time-Delay Vacuum-Tube Voltmeter

The voltage applied to the timing circuit, the plate voltage of the vtvm, and the delay bias voltage must be well regulated. A two-stage cascade voltage regulator is used for this purpose. The regulated output voltage which is applied to the timing circuit is adjustable plus or minus 2.5 percent from the front panel. This control is provided for making calibration adjustments to compensate for the effect of temperature variations on the timing circuit.

The range of the vtvm is determined by the value of the degenerative feedback resistance in the cathode circuit and the meter damping resistance.

If for any reason the gun should not completely fire the full number of rounds necessary to stop the timing action, the timing capacitor would continue to charge until the grid potential of the vtvm approached zero. The plate current would then overload the meter. To remedy this condition, an overload relay is used in the meter circuit and operates when the current exceeds full-scale readings.

The meter scale is non-linear because rate is an inverse function of time. This was also a reason for using delayed bias, since the meter would have otherwise read from infinity to 600 rounds per minute.

The divisions of the meter scale are individually calibrated. Calibration points were established by means of a variable low-frequency generator of known accuracy. The output of this generator was used to operate a polarized relay, the contacts of which were connected to the input of the indicator in the same manner as the mechanical switch unit.

Calibration Circuit

The accuracy of the indicator is greatly increased by means of a calibration circuit which generates pulse-repetition frequencies for checking and adjusting the meter indication. The greatest accuracy is

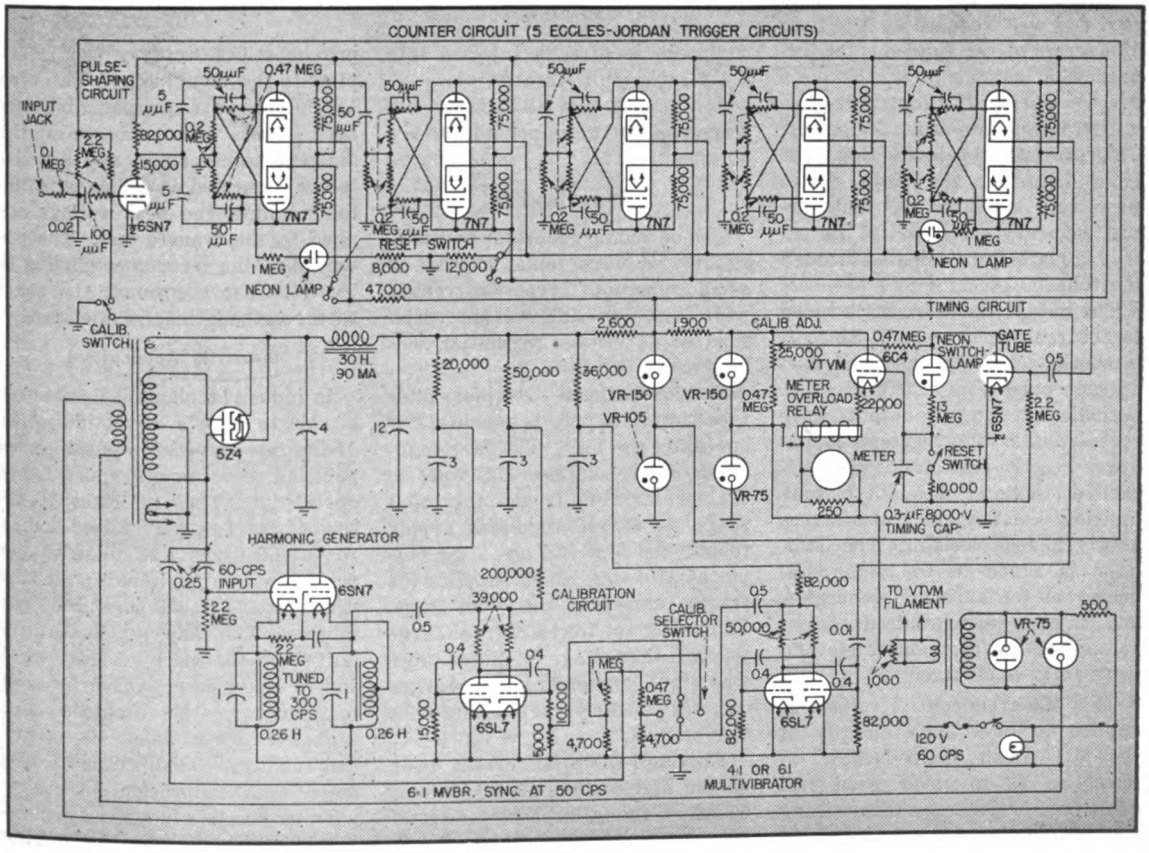

FIG. 3—Circuit diagram of rate-of-fire indicator, capable of indicating directly on a meter the rate of occurrence of any industrial or other operation in the range of from 600 to 900 operations per minute. The circuit can readily be adapted for other ranges

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required at 750 rounds per minute, corresponding to the rate of fire of .50 calibre machine guns. A multivibrator is sychronized to generate this frequency and also 600 and 900 cycles per minute to check both low and high ends of the meter scale. When generating 10 or 15 cycles per second, the multivibrator is directly controlled by the 60-cycle line frequency, functioning as a 6:1 or 4:1 frequency-dividing circuit. When generating 12.5 cycles per second, the multivibrator operates at a 4:1 ratio, and is synchronized by a 50-cycle source which in turn is controlled by the 60-cycle line frequency. This is accomplished by means of a harmonic generator which multiplies the line frequency by five and a multivibrator which divides the result by six.

The harmonic generator is excited from the high-voltage winding of the power transformer, resulting in a unusually high negative bias and a plate current pulse of short duration. The angle of plate current flow was reduced to less than 36 degrees at the fundamental frequency so as to cut off the plate current during the first half-cycle of the harmonic output frequency. This prevents the conducting tube from distorting the output wave form, and increases the tank circuit efficiency since part of its energy is not being dissipated through the tube.

The output tank circuit is tuned to 300 cycles per second. Since it is shock-excited by the plate current pulse every fifth cycle, a periodically damped output wave form results. This voltage is impressed on the grid circuit of a self-excited oscillator through a peak limiting resistor which also serves as a grid leak resistor. The oscillator is tuned to the same frequency as the harmonic generator, and thus a synchronized output voltage of uniform amplitude and wave form is obtained.

This 300-cycle control voltage is applied to both plate circuits of the 6:1 ratio multivibrator in phase so as to favor even frequency ratios, thereby maintaining the required frequency division over wider limits of voltage variation.

The output of this 50-cycle multivibrator is directly injected into a 4:1 ratio multivibrator, via a selector switch, and 12.5 cycles per second or 750 cycles per minute are obtained.

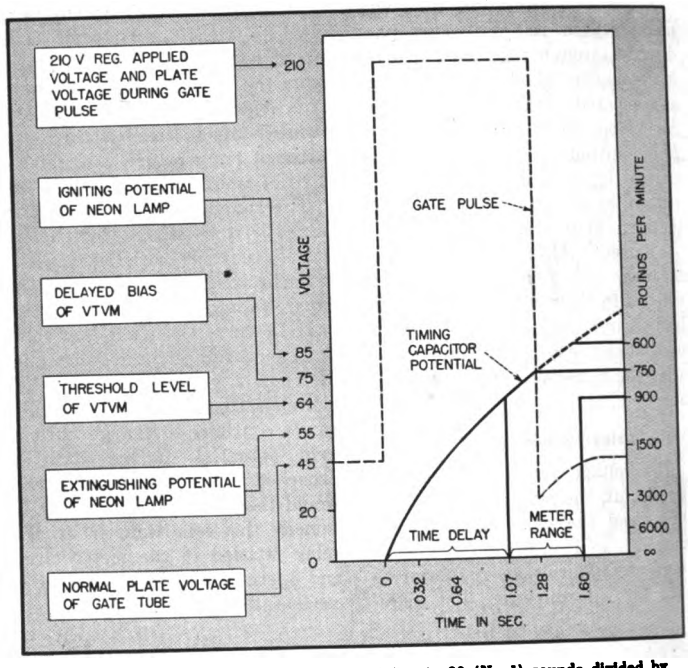

FIG. 4—Timing action of circuit. Rate of fire is 60 (*N*—1) rounds divided by the time interval

Power Supply

The harmonic generator and multivibrators were found to stay in synchronization over extremely wide limits of line voltage variation, so no voltage regulation was necessary.

A conventional rectifier-filter type voltage supply is provided for operating the unit. The first regulated output supplies 255 volts to the counter circuits and the input stage. A second regulated supply follows the first and has a d-c output of 210 volts which supplies the timing stage and the vtvm stage. To prevent the initial current surge through the voltage regulator tubes when the instrument is first turned on, a 5Z4 heater-type rectifier tube was selected.

Although the total current drain on the high-voltage supply is only 65 ma, a fairly large power transformer was used in order to supply the filament drain of 4.8 amperes.

The voltage-regulated supply for filaments has an a-c output of approximately 5 volts, which is applied to the vtvm heater. Two type VR-75 tubes are connected back-to-back across the primary of the filament transformer, and a resistor is connected in series with the line to limit the peak voltage applied to the transformer. The potential of the secondary winding is 75 volts above ground, the same as the cathode bias of the vtvm.

Industrial Applications

In industrial plants it is often desirable to have a direct indication of the rate at which a punch press, printing press, or other machine is operating. The instrument described can be used without change for applications like these if the action being monitored is in the range of 600 to 900 movements per minute. The only attachment required on the machine is a simple switch that operates once for each movement to be counted. For higher or lower rates, the circuit can readily be modified and a new meter scale calibration obtained.

Other possible industrial applications include monitoring of life tests and acceptance tests of electromagnetic devices like relays and solenoid valves.

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By L. E. PINNEY
Assistant Professor of Physics
Iowa State College
Ames, Iowa

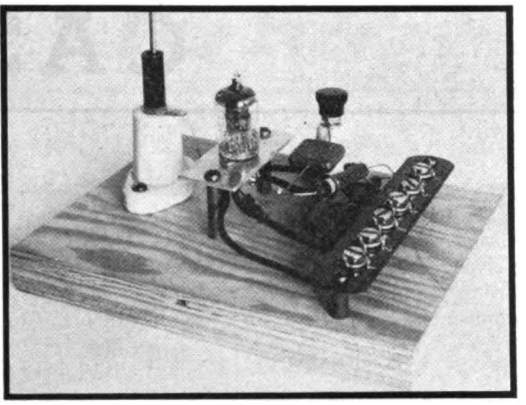

FIG. 2—Experimental mixer layout. The large stand-off insulator supports a three-foot antenna; the small stand-off connects to the antenna post of a conventional receiver

Checking UHF Oscillator Stability

Design of a simple mixer that permits heterodyning an uhf oscillator against a crystal-controlled multiplier. The difference frequency is fed to a conventional receiver to observe frequency shift

FOR COMPARING oscillator frequencies by the heterodyne method, the simple circuit shown in Fig. 1 has been used with excellent results. The device is used with an ordinary all-wave radio, or better, with a communications receiver which responds to the difference frequency of the two oscillators. Audible response is obtained by heterodyning the intermediate frequency of the receiver to a suitable audio frequency, as in c-w telegraph reception, or by modulating one of the oscillators.

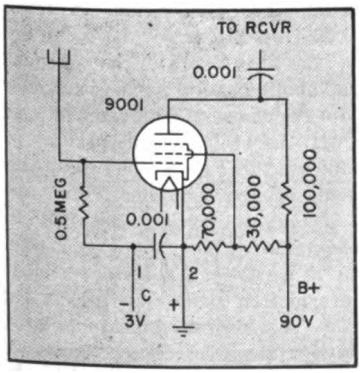

FIG. 1—Untuned mixer for comparing the frequency of an uhf oscillator with that of a crystal-controlled multiplier. Terminals 1 and 2 may be connected together if a plate potential of 45 volts is used

The antenna post of the receiver is connected through a capacitor to the plate circuit of the mixer shown in the diagram. This connection is made at the binding post on the small stand-off insulator, visible in Fig. 2. The mixer-unit antenna is a suitable length of heavy wire, ordinarily about three feet, plugged into the larger stand-off insulator.

Optimum values of external grid bias for the mixer range from 2 or 3 volts with 100 volts on the plate to zero at 45 volts on the plate. Since operation at the lower voltage is often quite satisfactory, it has been found convenient in such cases to connect terminals 1 and 2 together and to use a 45-volt B battery. The plate current at this voltage is about one milliampere. Grid-leak bias might also be used at higher plate voltages by omitting the grid-return capacitor and adjusting the grid resistor.

The oscillator whose frequency stability is to be observed is operated in the same room with the mixer (which is connected to the receiver) and a crystal-controlled frequency multiplier that gives a very stable signal at about 112 mc.

Operation

The oscillator under test is adjusted to a frequency such that the difference between it and the frequency of the crystal-controlled multiplier may be tuned in on the receiver. Thus, if the oscillator under test operates at a frequency of 100 mc, and the receiver is capable of detecting frequency variations of 1 kc, frequency instability amounting to 1 part in 100,000 may be observed. For maximum sensitivity, the difference frequency should fall in the range of highest resolution of the receiver. For most receivers, this optimum value is in the lowest frequency band.

Since the mixer is essentially untuned, it will respond to all the lower frequencies used in communications. Nearby broadcasting stations may be heard at almost any setting on the receiver dial by operating an ordinary test oscillator, adjusted to a suitable frequency, in the vicinity of the mixer.

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CASE STUDIES

By MICHAEL LECHNER
Production Engineer
Stamford, Conn.

DURING the past two years, the following four production problems were encountered and solved in the plants of four electronic equipment manufacturing companies.

Problem No. 1

The first problem involved setting up the process and increasing production on four units comprising a uhf radar receiver. It consisted of a mixer-converter, power pack, i-f section, and video sweep section which were assembled on separate lines and later combined with additional equipment as one complete unit which moved first to company inspection and testing and then to Government inspection and final test.

Figure 1 shows the floor layout where the problem was handled. Note the proximity of all major sections to each other. Resistor boards, cabling, and other sections were set up as subassemblies and, because of required compactness, each was small.

Since the workmanship required was very exacting and the work often inaccessible, this was no mass production item comparable with those found in the three succeeding problems. Workers needed on assembly, wiring, and soldering required skill considerably higher than that found in average factories. Thus a school was maintained separate from production. There, every girl was taught to read resistor and capacitor values, wire stripping, tinning, and all types of soldering. Under the supervision of an experienced teacher, workers left the school as skilled mechanics.

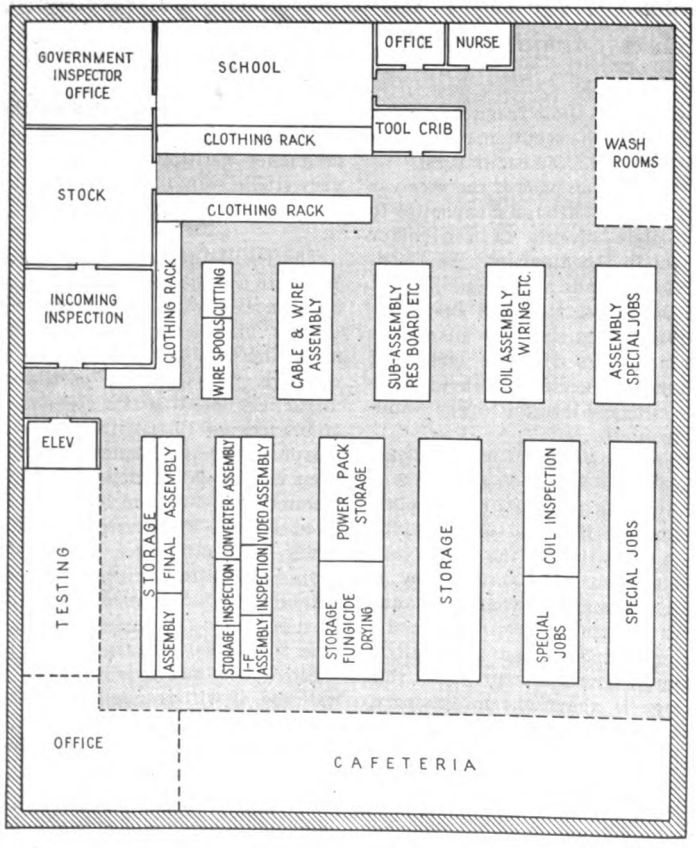

FIG. 1—Production-floor layout for radar manufacture described in the text under problem No. 1

The first unit to consider is the converter section. The chassis itself was 4 x 9 in. Into this small space were crowded 6 tubes, 5 jacks, 90 screws, 44 nuts and about 125 solder joints, with a large number of other parts. To add further production difficulties the chassis was subdivided with panels.

There were two ways to consider handling the converter section: (1) having wires and parts crimped by one operator and connections soldered by another, or (2) having each operator responsible for wiring and soldering a complete box. We tried the latter. This job required very skilled girls in each position. By the first method we could have sandwiched in fewer skilled operators.

The first operator on assembly had about 25 solid parts to assemble into the chassis. So a ramp storage shelf was built for this position as indicated in Fig. 2. The ramp was made of plywood. The boxes were paper and nailed into the stand. In back of each box (X) was included on a white paper strip pertinent information about the parts in the box. This strip was fixed into place with transparent Scotch tape.

Good features of the ramp were its low cost and re-usable value and the fact that the supervisor could tell at a glance what parts or hardware were needed. The operator

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OF PRODUCTION

Details of what one engineer did to raise productivity in four different plants manufacturing electronic gear. He shows how consideration was given not only to the tangible jigs and fixtures but also to the more abstract factors of personnel relationships

A typical electronic equipment production line in action

was clocked working the same job with a conventional type half-circle parts holder at thirty minutes and with the ramp at twenty. Each box was fixed so the operator could follow only the set routine.

At the start, the first operator was assembling one tube socket or one part at a time. A jig was devised which cost about $15.00. It is shown in Fig. 3. Now the operator could assemble 10 parts at one time. This was done by first assembling 20 nuts on a piece of rod, then dropping one into each Spintite. In the same fashion a lockwasher is put on top of each nut. Then the chassis is placed downward on the Spintites, parts are set in place and the screws threaded home.

On the next assembly operation an all-purpose wooden hardware holder of the type in Fig 4A was being used. Slots were made for hanging-in small metal pans, as in Fig 4B, when additional storage was required for small parts, and a half-circle group of four wooden holders were utilized when the assembly operation warranted.

After the assembly section there was a storage pen made of shelving and 3-in. pegs of wood, like that in Fig 5A, so the sets could be stacked on end, while single sets were kept in pens of the type shown in Fig 5B.

For the chassis wirers and solderers wooden holders were made as shown in Fig. 6. They were made so the chassis could be reversed sideways for easier operation, and the few parts required were directly in front of the operator. Tacked up within visible range was a blowup of the operation. Resistors, and sometimes the wires, were colored in these diagrams.

In complicated sets it is best to have a first-inspection tag on each chassis which means the chassis is complete and correct in every detail including stencils. This particular unit has ½ by ⅛-in. stencils. If there is any great quantity of these it is advisable to use templates and a spray gun. The next

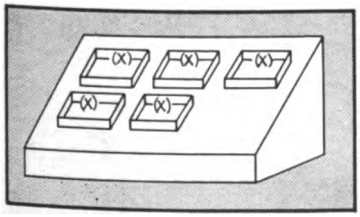

FIG. 2—Plywood ramp holds solid parts in storage for assembly. Identification is fastened in at X with transparent tape

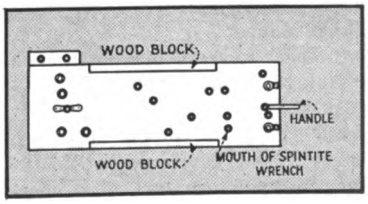

FIG. 3—Twenty Spintite wrenches incorporated into this jig made it possible for an operator to install ten parts on a chassis at once

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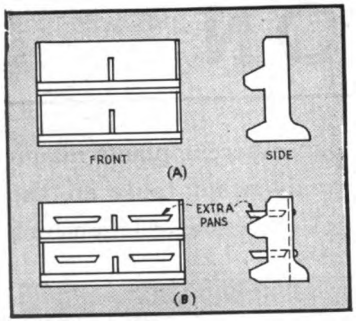

FIG. 4—Standard hardware holder, A, is modified as at B to give extra space for small parts at various positions on assembly line

inspection should follow the assembly section. The tag on the chassis will include the repairs found necessary, the initials of the repairer and the inspector's number. On critical, compact work, if an inspection is not made at this point the cost of repairs later is extreme. It also lessens the work and the field of inspection of the final inspector and chances of ultimate rejection by the government inspectors is much less.

In the i-f section, another jig of Spintites was prepared for seven tubes and jacks. This operation was cut five minutes with the jig. Originally, each operator tried to do wiring and soldering in the i-f section chassis on the table. A simple wooden holder was made like that illustrated in Fig. 7. This jig held the protruding coil cans firmly in place and could be moved or slid around at will.

Work being in an open chassis, things were arranged so wiring, jumpers, and resistors were crimped-in by operators and the chassis was moved down the line for another operator to solder these. Then the next operator would do more crimping and another more soldering. This method did not require all personnel to be highly skilled.

In order to keep coils on the line a bank of squares shown in Fig. 8 was used.

For the power-supply section a simple jig was developed for mounting can-type capacitors. The operator inserted the can into a metal holder, then pushed the bare chassis down and installed the necessary lockwashers and hex nuts. This method saved about three minutes on each chassis. Also, operators will do better work if a chassis has a solid or firm foundation under it while they perform their operation.

In the video section the assembly operator was spending fifteen minutes to assemble three tube sockets, which had a fixed and springy tube clamp. An assembling tool, Fig. 10, was made inexpensively of ½-in. tool rod. With this tool, which cost about $8, the operation was cut from fifteen minutes to five and a half.

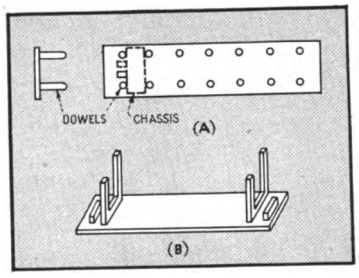

FIG. 5—Following assembly, radar chasses were stacked on end in pens like A. Rack B serves similar purpose for a single unit

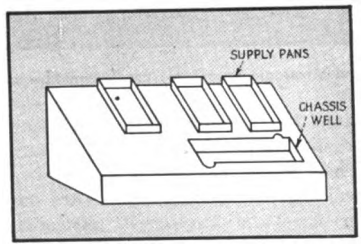

FIG. 6—Many wiring and soldering operations were handled in ramps like this. Chassis-well was made to hold units in several positions and at proper angle for light and access

The video-section line required one operator to insert four cables of different sizes and colors, so the holder of Fig. 11 was contrived. It was made of light wood and just about 4 inches short for each cable so the protruding cable ends could be grasped easily. The highest point was within easy reach of the operator.

Some simple chassis holders were made of wood. See Fig. 12. With this pitch, the most light from overhead reached all parts of the set. The arrangement also prevented operators from continuously blocking the light, and from becoming fatigued by bending over.

Problem No. 2

The second problem to be met concerned production of 8-tube recorders, subassemblies and assembly and wiring for uhf amplifiers and generators. The results were as follows: Recorder labor costs were cut from $20 each to $11. Subassembly labor time was reduced 60 percent. General production of main assemblies increased 70 percent.

The floor section was set up as shown in Fig. 13. Note that wire cutting and cabling adjoin and that both are close to the production sections.

The recorder chassis was cumbersome because side brackets which can be seen in Fig. 14, were being assembled at position one. A chassis should be easy to handle on a production line. Assembly of brackets was changed to the end of the line.

Tables were covered with heavy paper so the chassis could be slid along in an upright position. All heavy wires were put in first, close to the chassis. Then jumpers and connections were added.

Supplies were prepared for solid runs of 50 units at a time and production stock control sheets were kept up to date—weekly for an overall check. After a time check for each position the process was set so that the assemblers were at least a few units ahead of the capacity of the three lines.

In the cabling section, production was increased 25 percent by the use of colored lines and tracers to duplicate the cable proper. This was on a large board slightly to the

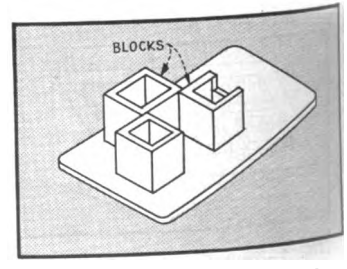

FIG. 7—Chassis holder of this type steadies inverted unit for wiring and facilitates soldering

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Problem No. 1

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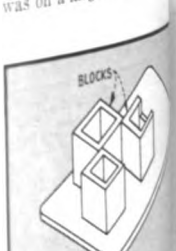

FIG. 7—Chassis
stacolles inverted
facilitates

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left of each cabler. Smaller cabling boards were put on swivels, as seen in Fig. 15. These are easy to swing yet they bind while a girl is working.

On resistor board subassemblies we cut labor time about 30 percent by using a small rack of step-up shelves as shown in Fig. 16. On these, tagged paper boxes were directly in line of vision of the operator. Each box was nailed down so it could not be moved. It was set to follow the process in correct sequence. This eliminated lots of errors. Resistors and mica capacitors were handled the same way.

For the wiring of resistor boards we used two devices shown in Fig. 17. For a 12-in. board wired on one side, Fig. 17A was used and, although there was a slight spring deflection when the girls wired, they liked it because it gave them a sense of openness and freedom while they worked. Another jig, Fig. 17B, was used for resistor boards from 3½ to 6 in. in length. Large resistor boards were divided into three operations. First, crimp jumpers, base wires, and sleeved wires; next, set-in wires and some resistors; third, finish crimping and solder all connections.

Hot irons and carbon tetrachloride fumes are not pleasant, so cleaning of solder joints was done well along at the end of the table. However, if the solderer is taught to hold her iron just long enough to get a clean finish on the joint, there never need be too much rosin there. This time factor depends on the thickness of the solder, its alloy, and the size of the iron, and it can be determined by the supervisor who makes a few practical tests himself. Thousands of connections were made which required no cleaning.

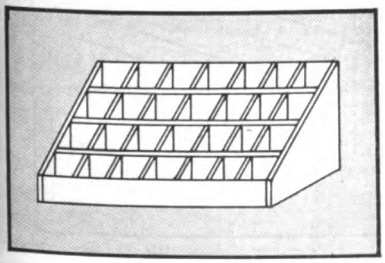

FIG. 8—Bank of squares was made to size for holding a supply of coils at their assembly point on the line

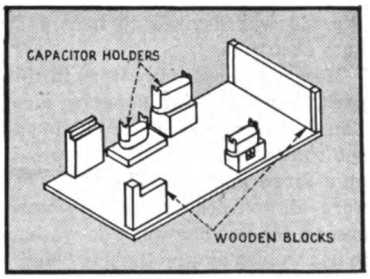

FIG. 9—Can-type capacitors were added to chassis with the aid of this kind of jig. Holders were loaded first, then the inverted chassis was dropped on top and washers and nuts put in place

For the large high-frequency amplifiers and generators, each operator had a little moveable stand as illustrated in Fig. 18, with each wire identified and its ultimate connection shown. This was enclosed in a thin plastiglass cover to keep it clean. It is advisable to make these for operations which exceed twenty connections, both to prevent forgetting over a weekend holiday and to guide a new operator.

Problem No. 3

The third problem was to improve production on power-supply units used for aircraft high-frequency transmitters. Production of 190 per month was increased to over 1000 per month in five weeks with the labor force increased 25 percent. Production cost at 190 per month was $15.00 each; at 1000 per month, $4.50 each.

On the mechanical assembly line, large terminal lugs were being removed from 4-in. upright can capacitors and replaced with smaller ones. A girl was holding the can in her left hand and using an open-end wrench with the other. She was doing about 110 per eight-hour day. A simple fixture like that in Fig. 19 was made and fastened to the table. The cans were inserted into the sockets, leaving the girl's left hand free. Two days after the jig was used a normal day's run for the same operation was 260 per day.

Another operator assembling 4 tube sockets into the chassis used an assisting jig which had an unsteady base. She was doing 25 units a day. The jig was placed on a wider paddle base. Her production moved up to an easy 55 per day.

An operator on the assembly sec-

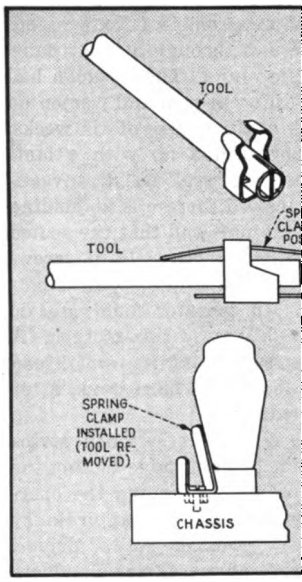

FIG. 10—Special tool saved 9½ m on each unit in the assembly of tube sockets and clamps. Made in. tool rod, it cost about $

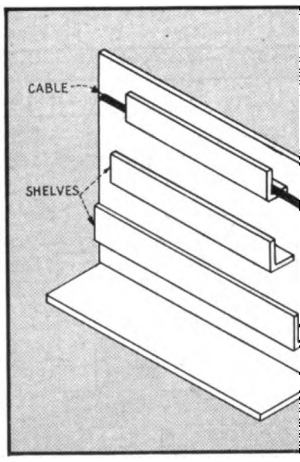

FIG. 11—Angle shelves were de to hold four different cables stallation in chassis. For easy shelves were about four inches than cables

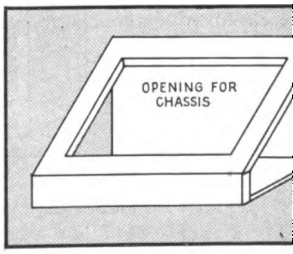

FIG. 12—Angle of pitch in this chassis holder is such as to c good light and a restful workin ture

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tion had to assemble 4 No. 8 round-head screws through a front panel into 4 stop nuts. The foreman had used 5 different men and women on this job in the course of six weeks. Each one wound up with a lame shoulder or a weak wrist. Investigation showed there was no holding jig for the unit and that the seated operator used a heavy 14-in. screwdriver. This operation was a bottleneck. An operator could only do about 30 a day by this method. A heavy screw cutting its own thread into a stop nut is hard work, after the first dozen.

Three 1 by 1-in. wooden strips were nailed on the table to stop the chassis from moving and the operator was supplied with an ordinary carpenters' ratchet screw driver. There were no more lame shoulders and sprained wrists. The practice had been to use an open-end wrench on the inside of the chassis—the operator holding one stop nut at a time. The simple steel jig shown in Fig. 20 was devised to hold four nuts at a time.

Most of the assembly work in this particular case was done by men. There still persisted the old bugaboo that a woman couldn't tighten up a screw and nut. The men, who were all too scarce anyway, were needed for heavier work so we had to use women or stop the job. Therefore, we taught girls who figuratively never saw a screwdriver before how to do a good job. They listened and they were shown how.

We got the correct screw driver to fit the particular screw slot. We got them correct chairs, taught them how they could burr a screw and how to avoid it, and showed them how to rest while they threaded the screw and only use pressure in the last turn and a half. Wherever possible we used a Spintite or a combination with a short holding screw driver. After two weeks women were producing more than the men.

Production of a five-tube superheterodyne receiver was to be raised from 70 each 8-hour day. Three weeks later it was 190-210 each day.

Here's how it was done:

Main production lines were set up with other sections nearby as shown in Fig. 21. Note that machines and heavy noisemakers were kept away from the assembly lines and that there are numerous storage spaces for sets. Notice also the accessible position of the cage.

The chassis itself was about 6

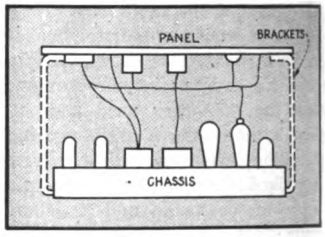

FIG. 14—Open side view of recorder. Panel and chassis were joined with side brackets at the end of the line instead of at the beginning of the line to keep the chassis easy to handle

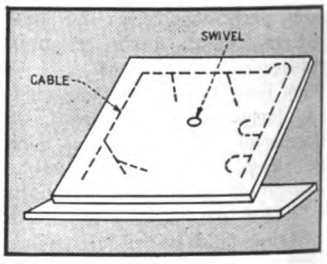

FIG. 15—Swivel boards for wire cabling turn easily but bind under pressure of operator's hands. A drawing of finished cable is taped down on board and nails and cleats added for cabler to follow

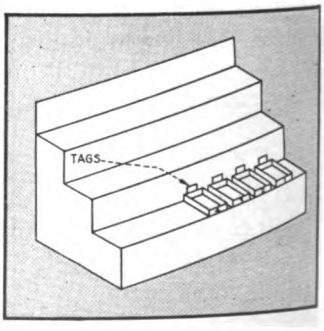

FIG. 16—For subassembly of resistor boards, parts boxes were fastened in position and tagged as shown. Ideal location is at eye level

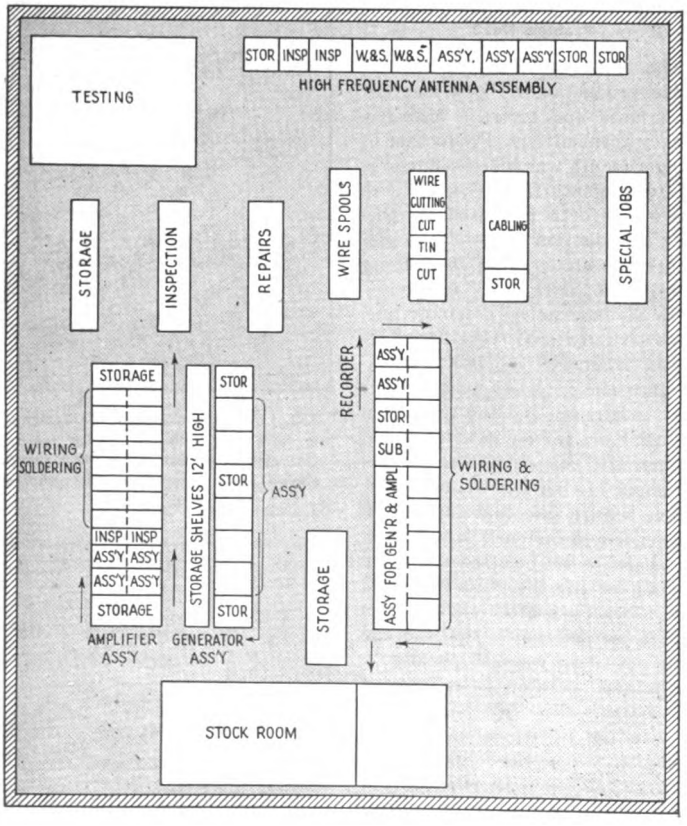

FIG. 13—Plant arrangement on recorder, amplifier, and generator project listed in the text as problem No. 2

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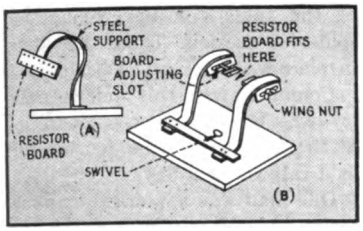

FIG. 17—Holding jig for 12-in. wiring resistor board is shown at A. Operators like it because of accessibility. Double-sided boards were wired in a fixture like B, which revolves

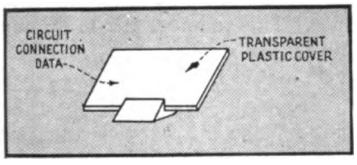

FIG. 18—Where an operation includes more than twenty connections, a small movable stand is helpful to display a sketch of wires and connections. Data is covered with sheet of transparent plastic to keep it clean

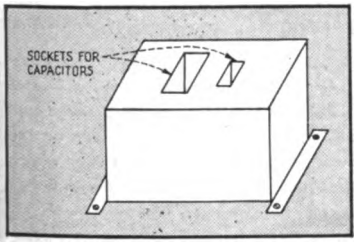

FIG. 19—Fixture designed to hold can-type capacitors while an operation was performed on the connecting lugs. This arrangement left both hands free

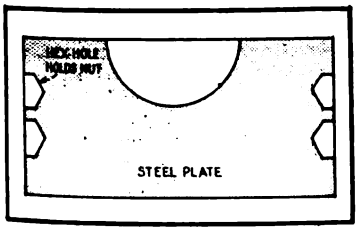

FIG. 20—This unit replaced an open-end wrench for holding four stop nuts behind a panel while screws were driven through with a carpenters' ratchet screw driver

by 11 in. and was set up on a jig and ramp combination as illustrated in Fig. 22.

For assembly of the i-f coils and the capacitor gang we used two power-driven screw drivers. These were on balanced pulleys which swing easily up or down. With these, production time on this operation was cut from 4 minutes to 1 minute even.

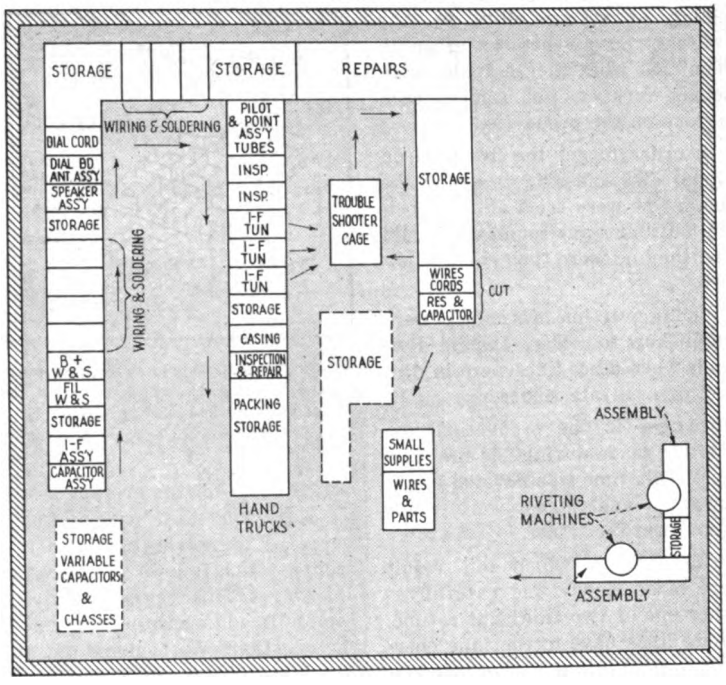

FIG. 21—Five-tube superheterodyne receivers were built in this layout, discussed under problem No. 4. Noisy riveting machines are well away from other operations

Tube sockets were being riveted by operators who had not been trained to judge their foot pressure correctly. As a result they were battering rivets and wasting lots of motion and time. After three days of careful instruction, 200 units a day were rolling away from these two.

After making a time check of each position, all operations were broken down to 1½ minutes. Each operation was simplified. All resistors, wires, paper capacitors, and cords were pre-cut to size.

An accurate metal-on-wood jig was set up for the speaker assembly and it increased production 200 percent. All operators had a good supply of parts before them at all times.

One operator learned or worked faster than another. If she piled up her next neighbor, these extra sets were stored in boxes elsewhere and worked into the line a few at a time about two weeks later.

If one operator was too fast for her operation, part of a slower operator's work would be diverted for her to help out. Eventually it became incorporated into her operation. This way a line can be balanced.

All supplies were put into fixed boxes on ramp stands. They were so set and filled that they had to be picked from right to left in an order we believed to be the best method.

Each operator was encouraged to memorize every point-to-point connection to cut out waste motion. With a little patience most of them knew their job thoroughly after the second day.

Problems with People

The following are notes on the psychological factors involved in the various projects which have been described.

At the plant involved in Problem No. 2, too many men and women were spending too much time in their respective rest rooms. It was pointed out to supervisors and employees, tactfully, that a longer and more healthful life would be induced at the work tables than in smoke-filled rooms.

For a week or two, a few workers who were lagging were shifted every few days to give them a sense of shortlived security. It worked wonderfully.

Indifferent supervision in the past had resulted in a loss of any

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feeling of responsibility by the workers. So we had to prove to them that what they did was final. Repair work was not brought back to them on the production line.

In order to get the first girl on wiring and soldering to spark the line, a few were tried at this position until one was found who could feed the line more than it could absorb.

During overtime, assemblers were taught how to solder. It paid dividends when other lines were in dire need of first-rate solderers.

Changes in the production line were not made during the first few days. This time was devoted to observation and notes were made away from the tables.

The changes which did result were made slowly and carefully—either one or two things at a time. Where lines have to continue operating to maintain a minimum quota, any change, no matter how small, must first be approved by the operator. She must be sold the idea, otherwise the foreman or engineer will meet the proverbial stone wall.

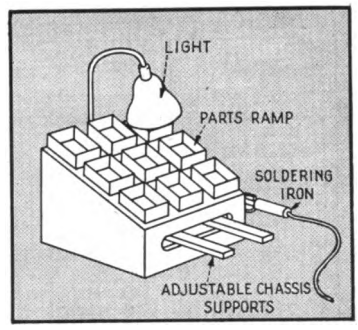

FIG. 22—Chassis-holding jig and parts ramp were combined in this unit for assembly of five-tube receivers. Note soldering iron in support at right

It is usual for the average assembly section to move with the same tempo as the wiring and soldering section which follows. At plant No. 3, however, time was of the essence. Simply to add operators was out of the question. We couldn't get any. The big problem was to have operators do 60 sets a day where they had been doing 20.

So the assembly section alone was kept working overtime the first week. The units were loaded on trucks and kept right at the head of the table for the wiring and soldering section. There they stood in plain view for all to behold.

Combined with this spur to activity was the excellent co-operation of the first wirer who fed the line at a rate of 60 a day.

One man was appointed as a material expeditor. His duties required a visit with each foreman twice a day. It was his job to act as liaison between production, stock, and purchasing. This arrangement kept the foremen at their respective lines. This man saved everybody lots of leg work, and his appointment was well worth the cost.

Frequently we were short of parts. When this happened, the unfinished units were not allowed to clutter up the tables. They were kept on trucks, shelves, or under the table, but never in direct sight of the workers. Later, when the parts were received, the unfinished units were fed into the line without interrupting the continual production pace.

In plant No. 4 one problem was to sell the operator who wired and soldered tube filament wires on the idea of producing 200 a day where she had been doing 70. She was asked to operate for a day as a guinea pig in time study. She practiced some of the suggestions she was given. Because of a desire to impress us, she cut down on motions, and her daily production gradually moved up to 200 a day.

An attempt was made to interest the people on the line in daily quotas. After a week each line was competing with the other to gain that quota. To spur this on, hourly figures were posted in four spots on the production line. This way the operators were being paced hourly to avoid spurts in production.

When an operator consistently had similar rejective work, it was brought back for her to repair. That way she learned to avoid the same errors.

Each worker was required to learn her job from memory. Previously they had spent 20 percent of their time looking at the sample. Each knew the difference between what was acceptable and what was not. They were shown concrete examples of each kind, good and bad.

PEOPLE in PRODUCTION

A worker must be kept interested in her job, no matter how small or monotonous. She must feel she is contributing an important part of the entire job.

Each worker should understand the part the completed unit plays in the final function of the gear.

A production line crew should work as a team. Each individual must depend on the others. It is surprising how this one element will cut absenteeism.

If possible, workers should be arranged so neighbors are friendly, without the extremes where cliques are formed. In the event one girl slows up or is absent, her two neighbors will absorb her work for a day or so.

Contingent on maintenance of production, encourage word games, charades, etc. Tests show production is usually increased.

The most effective way to keep women workers from spending too much energy talking is to have amplified recorded music. Tempo of inter-mixed popular and classical records should vary.

It is a good practice to shift workers around on the same production line. Thus each one gets to know three or four operations and can fill in during an emergency when others are absent.

Workers must respect the foreman, whether they like him or not.

Race, color, and religious belief need cause no friction if competition between groups is eliminated.

It is a good point for the foreman or even top management to sit down once in a while and work on the line. Not too productive. But fine for morale.

Get operators to give their work a quick visual inspection before passing it on. It takes a few seconds but often saves more by keeping rejects out of inspection.

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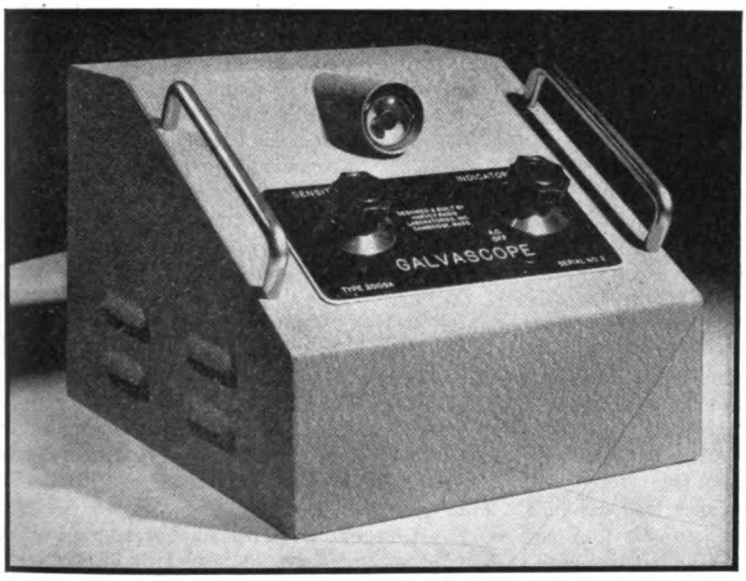
A-C Galvanometer

Operating theory, circuit analysis, and design considerations of a highly sensitive null indicator for a-c bridges. Stability and ruggedness are adequate for checking product quality in manufacturing plants. Nulls are indicated by a 6E5 electron-ray tube



Exterior of the electronic a-c galvanometer, showing hooded indicator tube and operating controls. The indicator bias knob at the right has an associated on-off switch for 115-v, 60-cycle a-c power. Tubes and other components are accessible after removal of bottom plate

By ARTHUR L. QUIRK and HENRY D. HALL

Chief Engineer *Senior Engineer*
Harvey Radio Laboratories, Inc.
Cambridge, Mass.

USE of headphones as a balance detector for a vacuum-tube bridge is generally unsatisfactory in a manufacturing plant or its laboratories due to a high noise level. The electronic a-c null indicator to be described provides high effective sensitivity for this purpose by a combination of two factors—high optical sensitivity and high electrical sensitivity. It also constitutes a more satisfactory method of detecting balance of an impedance bridge used to check incoming electrical components.

If balance of the bridge is to be precisely determined it is almost invariably necessary to determine an increment of minute value. For easiest optical detection, which in turn means greatest accuracy, the incremental angle must be as large a fraction as possible of the initial angle. This condition is realized with an initial angle of zero degrees. In another sense, this arrangement produces what might be regarded as optical amplification.

Indicator Circuit Requirements

In a type 6E5 electron-ray tube, a negative voltage of the order of 7.5 volts must be applied to the triode grid to cause eye closure (zero shadow angle), as shown in Fig. 1. Inspection of the characteristic of this tube shows that as the grid-cathode voltage is varied from zero to approximately minus 7.5 volts, corresponding to shadow-angles of 90 and 0 degrees respectively, the cathode current undergoes but slight change. This fact permits the use of a cathode resistor to produce operating bias.

Balance, as applied to an a-c bridge, is frequently a relative term, since many times complete balance is not secured; in fact, the nearest approach to a complete null may represent a minimum signal of some magnitude. Under such circumstances the balance indicator, to be satisfactory, must be sufficiently flexible to permit two major accomplishments, detection of a very small signal, and detection of a very small change in a relatively large signal. The first of these is required to take care of practically complete bridge balance, while the second is necessary to cover the more common case in which the residual signal is comparatively great. With proper handling of the controls, however, balance can be just as sharply displayed for a residual signal as for a virtually perfect bridge balance.

The detection of a small signal imposes two basic requirements. In the absence of signal the eye must be closed, but not overlapped. This requirement is easily met by bias voltage developed across the 6E5

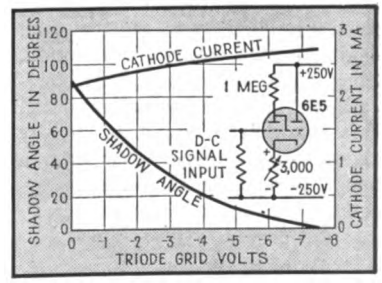


FIG. 1—Shadow angle vs grid voltage and corresponding change in cathode current for a type 6E5 tube used in the circuit shown

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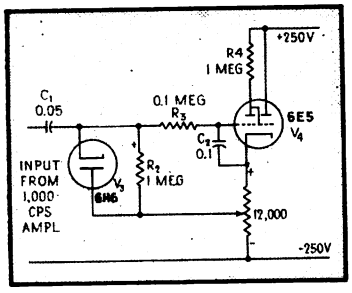

FIG. 2—Indicator and rectifier circuit

cathode resistor, which is preferably made variable. The second requirement is that the electrical sensitivity be high, and this is satisfied by a high-gain a-c amplifier which in this instance is tuned to 1,000 cycles.

Signal Rectifier and Low-Pass Filter

A signal rectifier and a low-pass filter are interposed between the amplifier output and the grid-cathode circuit of the indicator, as shown in Fig. 2. The filter is needed to secure sharp edges on the eye opening, since any rapid variation of indicator grid-cathode voltage would produce fuzzy edges. Obviously the filter has a longer time constant than is necessary to eliminate a 1,000-cycle ripple, but this arrangement helps minimize lower frequency a-c components such as 120 cycles. A still longer time constant would be desirable from the standpoint of removing 60-cycle ripple, but if the filter is made any larger the indicator becomes very sluggish. The chosen values seem to represent a good compromise.

The signal rectifier is so connected that the d-c output voltage acts in opposition to the initial bias. As noted above, the bias remains nearly constant for shadow angles from 0 to 90 degrees, and the small change is in a downward direction. Since it was a decrease in net grid-cathode voltage which produced this change the circuit is slightly regenerative, thereby causing a small increase in sensitivity.

Function of Rectifier Circuit

The 6H6 has a non-linear resistance characteristic in terms of the polarity of an applied potential, so that if the plate is positive with respect to the cathode the resistance is relatively low, while with reversed polarity the resistance is very high. If the shunt resistor has a value sufficiently high compared to the forward resistance of the diode, the parallel combination will exhibit a marked difference in resistance between potentials of opposite polarities.

The diode V_3 and resistor R_2 in Fig. 2 constitute the major portion of the load on the 1,000-cycle amplifier. This means that, if the diode is neglected for the moment, an alternating potential will appear across R_2. When the bottom end of R_2 is positive the diode will conduct and offer low resistance. On the next half cycle the diode plate is negative with respect to its cathode and will not conduct, thereby exhibiting high resistance. Since the driving source, the last amplifier stage, is a high-impedance device, it follows that the amount of voltage developed across its load is a function of the load impedance.

A low-impedance load thus develops a low voltage, while a high-impedance load develops a high voltage, so the top end of R_2 will average positive with respect to the bottom end. It is this voltage which after being filtered is applied between grid and cathode of the indicator, in series with the bias developed across the indicator cathode resistor. This new potential acts in opposition to the cathode bias, thereby opening the eye of the indicator.

For greatest rectification efficiency the resistor R_2 should be made as large as possible, but care must be exercised lest the resistance between grid and cathode of the indicator be increased to the point where instability appears. One megohm is a completely satisfactory compromise.

It is interesting to note that although the diode contact potential also acts in this circuit, its effect need not be taken into account because it is present at all times and is included in the initial bias adjustment (even though its value is unknown). Furthermore, tube noise and pickup within the instrument, and pickup in the bridge itself, can be biased out simply by turning off the bridge 1,000-cycle a-c source and adjusting the bias to produce eye closure.

Operation with Residual Signal

The detection of a small change in a relatively large signal requires that at balance the indicator shadow angle be zero degrees, and that the electrical sensitivity be high. In order to produce eye closure (without overlap) in the presence of signal, it is necessary to provide extra bias by increasing the cathode resistor shown in Fig. 1. Use of some 12,000 ohms, as shown in Fig. 2, produces a potential of 25 to 30 volts, depending on the individual tube. A portion of this voltage, ranging from a minimum of 7.5 volts to the full potential, depending on the magnitude

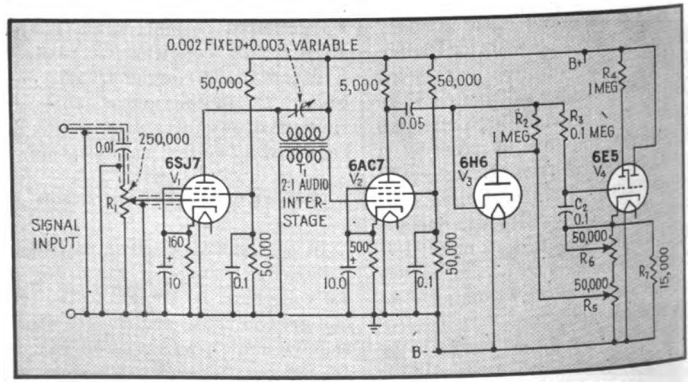

FIG. 3—Overall schematic circuit diagram of the electronic null detector. The conventional power supply is omitted. Sensitivity is controlled by R_1, indicator bias by R_5, and minimum bias by R_6

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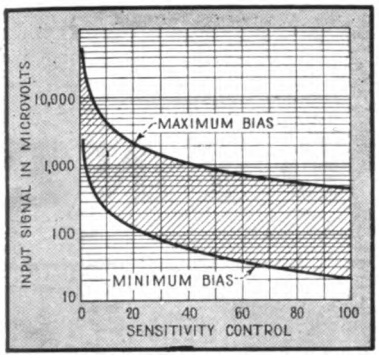

FIG. 4—Sensitivity control setting vs input signal for zero-degree eye opening over range of indicator bias

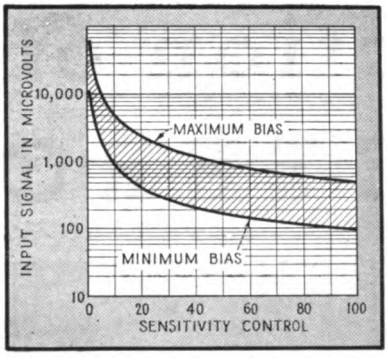

FIG. 5—Sensitivity control setting vs input signal for ten-degree eye opening over range of indicator bias

of the residual bridge signal, is applied to the indicator grid. When the algebraic sum of the two voltages is minus 7.5 volts on the grid the eye is closed, regardless of the magnitudes of the two individual voltages. The presence of extra bias and the absence of signal will cause the eye to overlap, and a certain amount of signal voltage is required to open it to the point where it is just closed. If the controls are correctly adjusted, the residual bridge signal, translated into a d-c signal, is just sufficient to produce zero-degree eye opening, while any departure from balance causes an increase in this signal which is displayed as an opening of the eye. The only additional requirement is that the amplifier must not overload under maximum voltage conditions, but this requirement is met by conventional a-c amplifier design.

Adjustment of Controls

The overall schematic circuit diagram appears in Fig. 3. The instrument is provided with two panel controls, one for sensitivity and the other for indicator bias. The sensitivity control is simply a gain control R_1 in the input circuit of the amplifier, while the indicator bias control is a potentiometer R_5 located in the cathode circuit of the 6E5. If a single variable resistor (or potentiometer) were used here it could not be turned through its entire range, because minimum bias of about 7.5 volts is needed at all times. The series resistor R_6 develops this minimum voltage, thereby making the panel control useful over its entire range. Variable resistor R_6 is screwdriver-adjusted so that minimum bias can be set exactly as required for operation or upon replacement of the 6E5. In practice, it is simpler to use relatively high-resistance potentiometers for R_5 and R_6, shunting them with a lower resistance. For this reason, a 15,000-ohm resistor is connected in parallel with the 50,000-ohm potentiometers.

Operating Limits

The sensitivity curves in Fig. 4 and 5 show performance for eye openings of 0 and 10 degrees respectively. The curve for minimum bias and zero angle is difficult to locate accurately, because it shows a barely detectable departure from exact eye closure. A signal any smaller would escape detection. It is not easy to make precise determination of this condition, which means that the accuracy of this limit curve is somewhat doubtful, although it serves to demonstrate that the instrument possesses good absolute sensitivity. Limit curves for eye openings of greater than zero degrees are far easier to determine, and reliance can be placed on their accuracy.

Figure 4 shows input voltages (1,000 cps) for zero-degree eye angle under various combinations of sensitivity and indicator bias control settings. The curve marked MINIMUM BIAS is one limit, and that marked MAXIMUM BIAS is the other limit. By reading vertically from any given sensitivity control setting it is possible to determine the range of signal which will produce zero-degree eye angle, depending upon the position of the indicator bias control.

Inspection of Fig. 4 shows that the minimum signal which can be detected is 20 μv. With the sensitivity control set at maximum, zero-degree eye opening can be secured with signals up to some 470 μv by proper adjustment of the indicator bias control.

Reference to Fig. 5 indicates that with minimum bias a signal of about 95 μv will produce a ten-degree eye opening, while with maximum bias this opening is produced by a signal of some 510 μv. By varying the amount of bias a ten-degree opening will result from the application of any signal between these limits.

All of the sensitivity data shown in Fig. 4 and 5 relates to absolute sensitivity. The incremental sensitivity is also important, and can be secured by use of these curves. Take, for instance, the case of maximum sensitivity and maximum bias. Figure 4 shows that 470 μv causes zero-degree opening, while Fig. 5 indicates that a signal of 510 μv produces a ten-degree opening. This means that an increment of 40 μv below an initial 510 μv, or some 8 percent change, is required to actuate the indicator over the optical range from ten to zero degrees. For precise work the maximum angle should not exceed ten degrees, and should preferably be nearer five degrees. If this angle is used the voltage increment is cut approximately in half.

Conclusion

Actual use of the instrument has proved that both the absolute and incremental sensitivity are as great as needed at any time. Under average conditions it is necessary to turn the sensitivity control down a bit in order to avoid very touchy bridge controls. Since the instrument contains no moving parts whatever, it is mechanically and electrically rugged, and cannot be damaged by mechanical shock or vibration or by electrical overload. Its operation is little affected by vibration, unlike the vibration-type a-c galvanometer, and stray fields of considerable magnitude do not influence it.

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Reduction of HETERODYNE

REDUCTION of constant-frequency interference such as is caused by heterodyne signals can be accomplished by utilizing the principle that heterodyne waves both amplitude and phase modulate the carrier of the desired signal. This method of interference reduction involves simultaneous detection of amplitude and quadrature modulation components of an interfering wave and subsequent canceling of the two detected outputs by balancing them against each other. The reception of desired signals, which are modulated in only one manner, remains unaffected.

The system is of particular advantage for communications in crowded bands where interference due to carrier heterodynes is objectionable, and increases the number of stations that can occupy a given frequency band without producing cross interference. In operation, the system to be described has attenuated strong interference heterodyne signals to below audibility with no apparent effect on the desired signal.

Principle of System

It is an accepted fact[1] that the sum of two waves is a wave which varies in both amplitude and phase. If one of the waves is taken as a reference, the second wave can be said to produce amplitude and phase modulation of this reference wave. In Fig. 1 let e_o be the reference wave, which may be the carrier wave of a desired signal, and let e_1 be the second wave, which may be an interfering and undesired signal. The combination of these waves can be resolved into a component e_2 which is in phase with the reference wave and produces pure amplitude modulation and a component e_3 which is in phase quadrature and produces pure phase modulation.

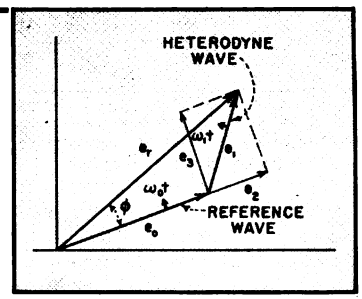

FIG. 1—Vector relations of two waves show phase and amplitude modulation of one by the other

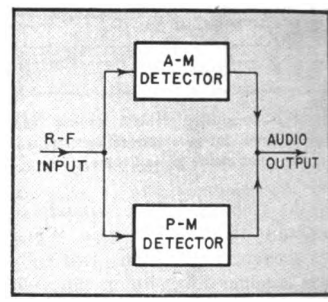

FIG. 2—System by which amplitude and phase, modulation components are independently detected

A heterodyne interference wave thus produces effects which differ from either those of a pure amplitude-modulated wave in which the resultant modulating vector is always exactly in phase with the carrier, or those of a narrow-band phase or frequency-modulated wave in which the resultant modulating vector may be in phase quadrature with the carrier.

The inherent characteristic of a heterodyne interference wave can be utilized to eliminate the interfering effects of the undesired wave in the reception of amplitude-modulated, or narrow-band phase or frequency-modulated signals, provided that suitable detection circuits as assumed in Fig. 2 can be devised. These detectors must be such that the amplitude-modulation detector responds only to sidebands which are in phase with a carrier, and the phase-modulation detector responds only to sidebands which are in phase quadrature with the carrier.

Principle of Detectors

Detectors devised by Crosby,[2] in which carrier segregation and amplification are utilized, are adaptable for this purpose. Referring to Fig. 3, the carrier, which has been derived from the desired signal by filtering or other means and then amplified, is applied to the balanced detector as shown. Also the entire received signal is applied in a balanced manner to the rectifiers.

In the absence of the carrier, there is no detection of the received signals, and in the presence of the carrier, only those resultant signal vectors which have components directly in phase or 180 degrees out of phase with the carrier are detected. For the a-m detector the segregated and amplified carrier should be in phase with the signal carrier, while for the p-m detector the segregated carrier should be in phase quadrature.

Basic Circuit

A more complete diagram of the system is shown in Fig. 4. The receiver i-f voltage is fed in parallel to a crystal filter for segregation of the signal carrier, and to two detectors through isolating amplifiers. The segregated carrier from the filter is amplified and fed to the two detectors, with the carrier voltage to one detector being shifted 90 degrees in phase.

One of the detectors detects amplitude modulation and the other detects quadrature modulation. For equal applied voltages, the outputs of the amplitude and quadrature detectors are equal. Thus, in the simultaneous reception, for example, of a pure a-m

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INTERFERENCE

Adjacent-channel signals produce both amplitude and phase modulation of the desired carrier. From separate detection of these two modulations, two interference signals are obtained which cancel each other leaving only the desired signal

By H. W. DELLES

Special Research Associate
Harvard University
Cambridge, Mass.

wave and a heterodyne interference wave, the amplitude-modulation detector will respond to both the a-m signal and to the heterodyne signal, while the quadrature detector will respond only to the heterodyne signal. Consequently if the output of the quadrature detector is combined in the proper phase with the output of the amplitude-modulation detector, cancellation of the detected heterodyne signal will result. The output of the quadrature detector must be shifted an additional 90 degrees to bring its output signal into opposition to the heterodyne signal from the other detector. Also the output of the quadrature detector must be shifted an additional 180 degrees when the heterodyne interference wave changes frequency from above to below that of the carrier.

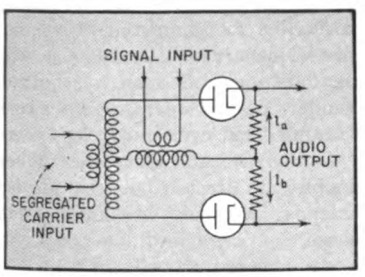

FIG. 3—Balanced rectifier is used to detect either a-m or p-m components of input, but not both

Effect of Segregated Carrier

Detecting systems, other than that described, are also usable. For example, a single diode to which the segregated carrier and received signal are applied will detect substantially only those signal components in phase with the segregated carrier, provided that the voltage of the segregated carrier greatly exceeds that of the total signal.

It is interesting to note the effects of the large phase shifts which occur in the crystal filter when the incoming carrier is slightly off resonance. One such effect causes detection of amplitude-modulated signals by the phase-modulation detector, because if the carrier is not at exactly 90 degrees phase difference with the amplitude-modulation components some detection of these components will result. This effect of carrier phase shift can be overcome by biasing the detectors so that the segregated carrier voltage will exceed the bias voltage only when the phase shift in the crystal filter is less than a predetermined amount which should be less than 45 degrees, at which condition the outputs from the two detectors are equal.

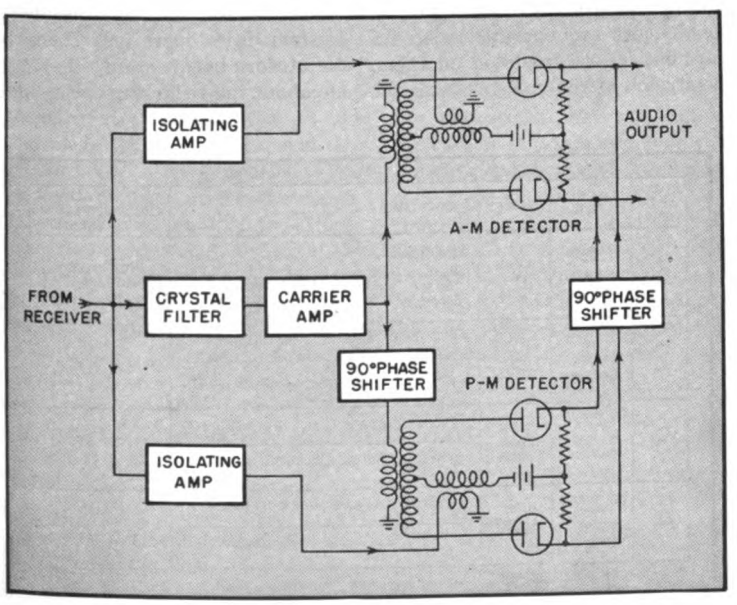

FIG. 4—By means of filters and phase shifters, the interfering carrier heterodyne can be eliminated in the detector stage, leaving only the desired signal

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(2) M. G. Crosby, Communication by Phase Modulation, *Proc. I.R.E.*, 27, p. 126, Feb., 1939.

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ELECTRONIC TIMER for Aircraft De-Icer

Inflation and deflation of de-icer boots is controlled by an electronic timer that makes available four different types of cycling to meet any icing condition encountered. Thyratron and diode in timing circuit control stepping of telephone-type automatic switch

By D. W. BLOSER and G. R. HOLT

Research Engineers, Eclipse-Pioneer Division
Bendix Aviation Corporation, Teterboro, N. J.

DE-ICER equipment as currently used on aircraft provides a constantly recurring cycle of inflation and deflation of tubes or boots along the leading edges of protected airfoils, with no controls or adjustments to govern either the frequency of inflation cycle or the completeness of boot inflation. Despite this lack of flexibility the rubber de-icer boot, functioning on a fixed cycle arbitrarily set at 40 seconds, has proved to be an effective ice-remover.

Icing conditions are not only variable, but completely unpredictable since ice does not form at a standard rate or to a standard texture. In recognition of a real need, therefore, a de-icer timer has been developed to control the operation of de-icers and to provide effective ice elimination under varying icing conditions.

Ice Buildup and Removal

The two principal factors in the problem of ice elimination are the adhesion of ice to the surface and the continuity of the ice. Although both factors are normally present, either factor alone will retain an ice accretion. The natural lock of an ice formation over the leading edge of an airfoil will hold that formation in place although its adhesion has been completely destroyed. Similarly, isolated particles of ice can be retained solely by their adhesion to the surface.

Fundamentally, de-icer operation is based upon playing the factors of continuity and adhesion against each other. It is because the ice adheres to the de-icer surface that inflation of the tube elements breaks the continuity of the ice along the leading edge. Conversely, it is because the ice has continuity and enough tensile strength to maintain that continuity that the stretch of the rubber produces a peeling action which destroys the adhesion and lets the airstream carry the ice away.

Years ago aircraft operators learned that de-icers give better ice removal if ice, at least an eighth of an inch thick, is allowed to accumulate before the boots are inflated. This is because the ice must build up to some definite thickness in order to develop enough tensile strength to overcome adhesion. If the de-icers are operated with insufficient ice accumulated on them, the stretch of the rubber crazes the thin layer of ice, breaking it into many very small pieces, some of which are dislodged but most of which remain. Then, further accumulation of ice builds on these remaining particles thus developing a flexible ice composed of a number of separate little islands. The establishment of such a condition renders de-icer operation on a continuing fixed cycle much less effective than normal since the rubber inclines to stretch between the ice islands without breaking them loose.

Importance of Timing

Although operators have learned to allow a buildup of ice to accumulate before putting the de-icer system into operation, there has heretofore been nothing they could do about the recurring cycles which

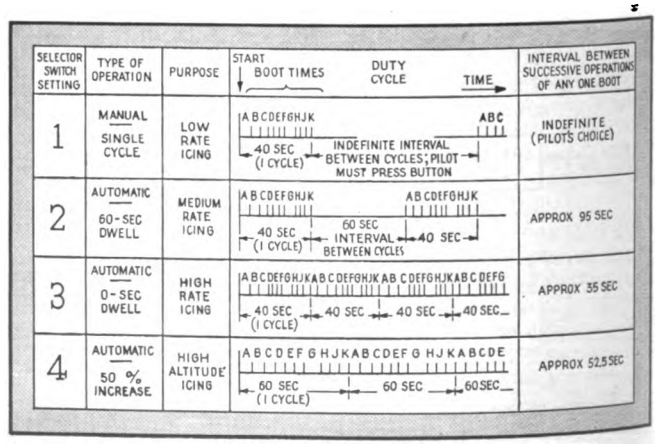

FIG. 1—Types of operating cycles available in the timer to meet various icing conditions encountered during all-weather flying

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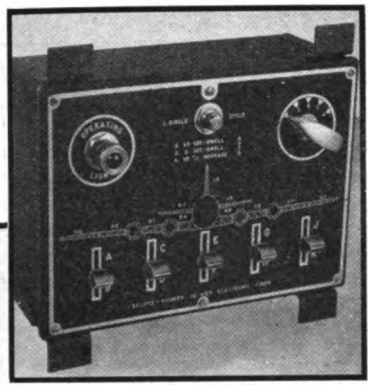
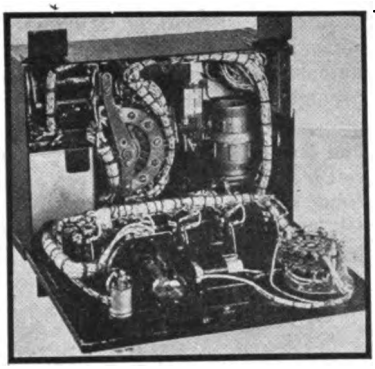


Eclipse-Pioneer electronic timer as built for use on four-engine aircraft. Cross-section drawing of plane indicates positions of de-icer boots controlled by the emergency manual toggle switches at bottom of control panel



Timer may be opened from the front and allowed to operate, for convenience in making adjustments or locating troubles. Selector switch (at lower right in this view) provides choice of four types of de-icer operation

automatically followed in sequence at intervals of approximately 40 seconds, other than to manually switch the de-icers on and off. If the rate of ice accretion was only moderate, the amount of ice built up between the first and second cycle was inadequate to afford good removal. Furthermore, if inflation was premature the ice deposit on the boots might become crazed and compromise the proper subsequent removal of ice.

The requirement, then, is for some controlled means of automatically closing switches in sequence at the most effective times for de-icing. The purpose of closing these switches is to complete a circuit to one or more distributor-valve solenoids, to control the opening of poppet valves and release a surge of pressure directly into the de-icer boot cells. These cells immediately punch out to a full inflation. The cells are deflated under their own pressure by unloading to atmosphere upon breaking the solenoid circuit through the timer. Suction accelerates the final stages of boot deflation.

For slushy ice, the rapidity of inflation is very important. With some types of de-icer systems, the inflation of boots is sluggish and as a result the ice sometimes has time to mold itself to the changing contour of the de-icer surface.

For very hard types of ice, the completeness of inflation and the resulting distortion of the rubber surfaces become more important than the rapidity of change. In the older systems completeness of inflation on the larger-capacity de-icer boots could only be satisfactorily obtained by recourse to oversize air pumps, with an attendant weight penalty.

Electronic De-icer Timer

The electronic de-icer timer to be described provides the needed flexible control of de-icer recycling when used with the manifold-solenoid de-icer system. This system replaces the central distributor and multiple tubing lines with pressure and suction manifolds acting in effect as reservoirs of both pressurized and evacuated air for the individual solenoid-controlled distributing valves located at the respective de-icer boot connections. The system not only simplifies the plumbing installation but also improves the rate of inflation and deflation of the de-icer tubes, and adds snap to this process by providing quick opening and shutting of valves along with preselection of inflation periods to suit the capacities of the respective boots. It reduces the control of inflations to an electrical circuit operating the solenoids for the most part automatically. Overriding manual controls permit the use of human judgement in anticipating or reacting to rapid changes in icing conditions.

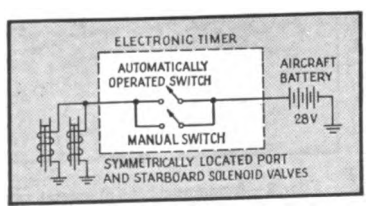


FIG. 2—One of the individual switching circuits controlled by the electronic timer

Choice of Operating Cycles

In the latest lightweight system of mechanical de-icing employing the electronic timer mechanism, positive control over all kinds of icing is provided by a choice of four different operating cycles, described below and diagrammed in Fig. 1.

(1) *Single Cycle,* in which the unit inflates each boot in turn once, after the starting button is depressed, and then waits until the starting button is again depressed before proceeding with another inflation cycle. This operation is useful under low-rate icing conditions.

(2) *60-Second Dwell,* in which the unit inflates each boot in turn, waits 60 seconds, then inflates the boot again, waits 60 seconds, etc, until the unit is turned off or switched to another position. This is preferable under medium-rate icing.

(3) *0-Second Dwell,* in which the unit keeps repeating the inflating cycle but does not delay between successive inflation cycles. This obviously provides for high-rate icing.

(4) *50% Increase,* in which the cycling is repetitive without delay between cycles, but the inflation period for each boot is increased by 50 percent. This operation provides for higher altitudes and subnormal air flows from the engine air pump.

Circuit Details

The electronic timer circuit consists of a multiplicity of simple switch circuits plus a combined timing and control circuit. One of the switch circuits is shown in Fig. 2. From five to ten of these circuits are provided, one for each pair of symmetrically located boots required on the aircraft. The automatically-operated switch closes once during each automatic cycle for a predetermined length of time provided for by an electronic timing circuit. The mechanical structure of the automatic switching mechanism is such that the individual circuits can be closed only in a fixed sequence and one at a time.

A schematic diagram of the auto-

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matic control circuit appears in Fig. 3. Contacts S_1, S_2, S_3, S_4, and P_1 (shown with dotted lines) are the contacts of the selector switch on the front panel and the SINGLE-CYCLE starting pushbutton respectively. These provide the four variations in cycling.

Position 11 on the automatic switch has been arbitrarily chosen as the DWELL position of the system, wherein no boots are inflated. In order to provide for SINGLE-CYCLE operation, contacts which are closed at all positions except 11 are connected in series with the stepping circuit, consisting of thyratron tube V_1 and the automatic switch operating coil. These contacts are known as the off-normal contacts, and are shunted by contacts S_1 and P_1. Since P_1 is normally open and S_1 is open on position 1 of the selector switch, the automatic switch cannot move off position 11 until either P_1 or S_1 closes. As soon as P_1 is pressed, however, the stepping circuit is completed and the automatic switch moves its contact arms to position 1. The off-normal contacts close, and operation continues until position 11 is reached again. In this manner SINGLE-CYCLE operation is obtained. When the selector switch is turned to any of the three automatic positions (2, 3, or 4), contact S_1 continuously shunts the off-normal springs and the automatic switch cannot stop at position 11.

Contact S_2 is closed at all positions except position 2, for 60 SECOND DWELL. When S_2 is closed, only 0.1 megohm is in the discharge circuit of the capacitor, and the time interval is 5 x 0.1 or 0.5 second. Since this resistor is at position 11 (DWELL) of the automatic switch, the delay between cycles is negligible. When S_2 is open at selector position 2, the resistance of the discharge circuit becomes 12.1 megohms, and the time interval of dwell becomes 5 x 12.1 or 60.5 sec (values are approximate).

Contact S_3 closes only at selector position 4 and connects a second capacitor in parallel with the one used for all other selector switch positions. This increases the capacitance in the timing circuits by a factor which increases all discharge times 50 percent.

Contact S_4 closes only in the off position of the selector switch, and when closed shunts tube V_1. The automatic switch then steps rapidly around to position 11, where the off-normal springs open the circuit, and the automatic switch operating coil is left connected to power. The timer is thus made to reset to the DWELL position no matter what its condition when the unit is turned off.

Stepping Operation

The stepping operation can be broken down into three repeating sequences of the telephone-type rotary switch. Wiper arms are mounted on a shaft, each wiper arm having an associated bank of contacts arranged in a semi-circle with the shaft as a center. When the shaft is rotated, the wipers connect to each contact in their respective banks in turn. There are eleven contacts in each bank, providing for 11 positions in one-half revolution of the wipers. The wipers extend on either side of the shaft, so that two cycles are obtained from one complete revolution. The operating coil, when energized, attracts an armature on the other end of which is a pawl that engages the ratchet wheel. This pawl moves back one tooth on the ratchet wheel when the armature is attracted by energizing the coil. An insulating button on the armature at the same time opens interrupter springs. When the coil is deenergized, a retractile spring restores the armature and in doing so the pawl drives the ratchet wheel, shaft, and wipers in a clockwise direction through an angle equal to the angular distance between contact centers in the switch bank. Therefore, each time the coil is energized, the switch prepares to step, and each time the coil is deenergized, the switch steps.

First Sequence

For convenience, let the first sequence begin at the instant at which current starts flowing through the coil, but before the resulting pull has overcome the inertia of the armature, corresponding to the conditions of Fig. 4A. At this instant the potential across capacitor C_1, and consequently the potential difference between grid and cathode of V_1, is zero and no current flows to or from C_1. Tube V_1 is passing current through the operating coil and its interrupter contacts, and capacitor C_2 charges with the polarity shown.

Second Sequence

When the coil pulls the armature fully down, the pawl is drawn back ready for stepping, the interrupter contacts are open and for a short space of time the conditions in Fig. 4B exist. The interrupter contacts

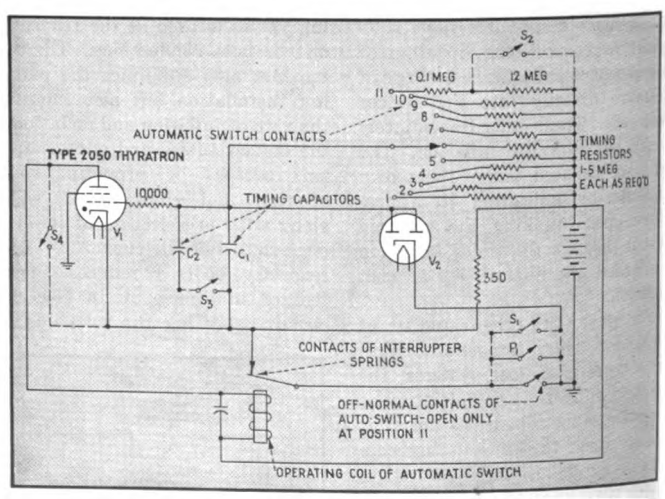

FIG. 3—Automatic control circuit used to operate ten de-icer boots on an aircraft. Stepper arms of automatic switch rest on position 11 during the DWELL interval between cycles. Other contacts (not shown) on the automatic telephone-type stepper switch energize solenoids that control boot inflation

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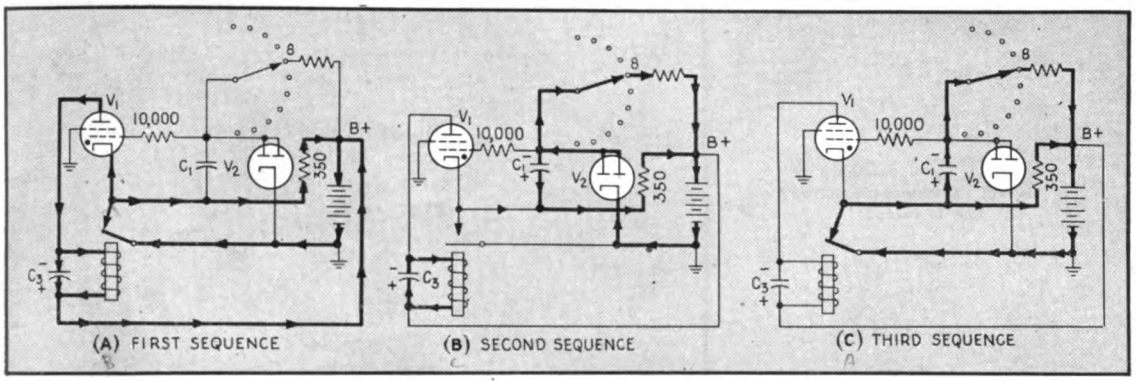

FIG. 4—Simplified versions of automatic control circuit, showing directions of electron flow for the three sequences occurring during a stepping operation associated with the inflation of one de-icer boot. The first and second sequences last approximately 0.05 second each, while the third sequence lasts for the duration of boot inflation time

are open, there is no path from the cathode of V_1 to ground, and the cathode is connected to B+ through the 350-ohm resistor. This places both plate and cathode of V_1 at the same potential and consequently no current flows in V_1. A small current flows for a short time between the coil and C_2, and C_3 discharges. The main current flow at this instant, however, is the charging current that flows from B+ through the 350-ohm resistor to the cathode side of C_1, and from the grid side of C_1 through tube V_2 to ground. Capacitor C_1 therefore charges with the polarity shown.

Third Sequence

At the end of this short interval during which the V_1 circuit is broken, the retractile spring of the automatic switch overcomes inertia and restores the armature to normal. The pawl drives the shaft and wipers to the next position, the interrupter springs close, and the circuit conditions of Fig. 4C exist. No current flows through V_1 and the coil because C_1 is still charged. The positive side of C_1 is connected to ground and the cathode, and the grid of V_1 is negative by the amount of the charge voltage, thus preventing the resumption of current flow in V_1. The plates of diode V_2 are connected to the grid and the negative side of C_1, while its cathode is connected to the positive side of C_1, and therefore no current can flow through V_2. There is a current path through which the charge on C_1 can leak off, however, formed by the battery and the resistor connected to the particular point on which the automatic switch wiper is resting. Since battery resistance is negligible, the time of discharge will depend only on the resistor and capacitor values. Discharge times for individual switch points are obtained by using different values of resistor. A flat percentage increase of all discharge times is obtained by adding additional capacitance in parallel with C_1.

As the charge on C_1 leaks off, the grid of V_1 becomes less and less negative, until finally it becomes approximately at the same potential as the cathode of V_1. Tube V_1 then passes current which energizes the automatic switch operating coil, and the system is at the condition of Fig. 4A again.

Adjusting Boot Inflation Time

During the discharge period of the timing cycle, the negative side of the capacitor is connected by the timing resistor to the positive side of the battery, thereby doubling the voltage across the capacitor and providing a nearly linear discharge rate over the voltage range to be used.

To facilitate changing the boot inflation times to agree with the requirements of a particular aircraft, the timing resistors are wired inside a standard AN plug connector which is in turn mounted on an receptacle inside the unit.

Contact Arrangements

Considerable effort was expended to reduce the number of contacts to a minimum. The contacts used for connecting to the various boot valves and the contacts that connect and disconnect additional resistors for different types of operation are mandatory. However, in the control and timing circuit, one pair of contacts (the interrupter springs) in conjunction with diode V_2 perform the functions of charging the capacitor, connecting it so that the grid is negative after charging, deionizing thyratron V_1, and breaking the circuit to the automatic switch coil after energization to cause it to step the wiper arms to the next position. If the diode were omitted, an additional set of contacts would be required to connect the grid side of the capacitor to ground during charging, and these contacts would have to be critically adjusted with respect to the interrupter springs so as not to provide a short-circuit path across the capacitor after charging.

The standard telephone-type automatic switch used in the timer has three banks of contacts, although only two are required for the circuit. By tying all the contacts in one bank to the power supply, connecting two sets of wipers in series, and using the contacts in the second bank to connect to the valves, it was possible to use the standard contacts of the switch to make and break, as well as carry, the three-ampere inductive load of the valve solenoids without appreciable deterioration of contacts over more than two hundred thousand operations. In terms of deicing time, this is enormous life, and considerable savings are effected in weight and complexity over a system wherein the telephone switch contacts carry, but don't break, the load current.

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Compact, rigid assembly of the vhf impedance-measuring unit is essential

VHF IMPEDANCE

By D. STANLEY HENRY

Don Lee Broadcasting System
Hollywood, Calif.

AN INSTRUMENT with which to measure impedance in terms of resistance and reactance through the range of frequencies which have been assigned to the commercial f-m and television services is needed. Below this range r-f bridges are satisfactory and above this range slotted-line measurements are convenient.[1]

The instrument to be described is small and compact so that it can be used in many places inaccessible with conventional equipment. The grounding problem, which is always important and often critical at these frequencies, offers little difficulty principally because the device is complete in itself.

Description of Method

The range can be quickly varied to suit the particular problem so that in most cases it is unnecessary to supplement the unknown impedance with a known reactance in order to bring the unknown impedance within range of the instrument. However, greatest accuracy is obtainable through the resistance and reactance ranges commonly encountered in antenna and transmission line measurements. The resistance range is approximately 30 to 1000 ohms, and at 100 mc the reactance range is approximately ±15 to 500 ohms. The reactance range depends on the capacitance range of the capacitor used for C_2 in Fig. 1 and 2.

Resistance measurements are made in terms of a ratio of the voltage developed across a resonant circuit to the voltage resulting when the unknown resistance is introduced into the circuit. The unknown reactance is measured in terms of the variation of reactance of an accurately calibrated capacitor that is required to return the measuring circuit to resonance.[2]

The most logical means of measuring voltage and indicating resonance is a vacuum tube voltmeter connected to a resonant circuit L_1C_1 as shown in Fig. 1. Because a voltage ratio is used, the voltmeter need not be calibrated if its law of deflection is known. One of the adjustments requires tuning to produce 70.7 percent of the voltage at resonance. This voltage would be one-half of the voltmeter reading at resonance if the voltmeter were square-law. The added sensitivity of this type of voltmeter is convenient for increased tuning accuracy.

A balanced-modulator circuit will insure square-law operation because only second-order terms appear in the plate circuit. A 100-μa meter with at least 50 dial divisions is satisfactory for the meter. The required balanced voltage for the voltmeter is obtained from the balanced circuit L_1C_1.

Assume Q_2 of resonant circuit L_2 C_2, C_3 is reasonably high so that R_2 can be neglected. Let Z_1 be the impedance seen by a series generator in circuit 2 of Fig. 1 when it is isolated from circuit 1, then

$$Z_1 = \frac{Z_2 Z_x}{Z_2 + Z_x}$$

When circuit 2 is coupled to circuit 1, the impedance appearing in circuit 1 due to circuit 2 is[3]

$$\frac{(\omega M)^2}{Z_1} = \frac{(\omega M)^2}{Z_2} + \frac{(\omega M)^2}{Z_x}$$

This equation shows that the various shunt impedances affect circuit 1 independently and any one may be added or removed without changing the effect of the others. Regardless of the physical arrangement of the unknown impedance, circuit 2 sees the equivalent resistance in parallel with the equivalent reactance. In cases where the series components are more desirable and useful, the parallel combination can be changed to the series equivalent.

It should be noted that the minimum capacitance of C_2 will appear across C_x as an unknown reactance but the effect of this reactance is constant and will not modify the value of the unknown because it

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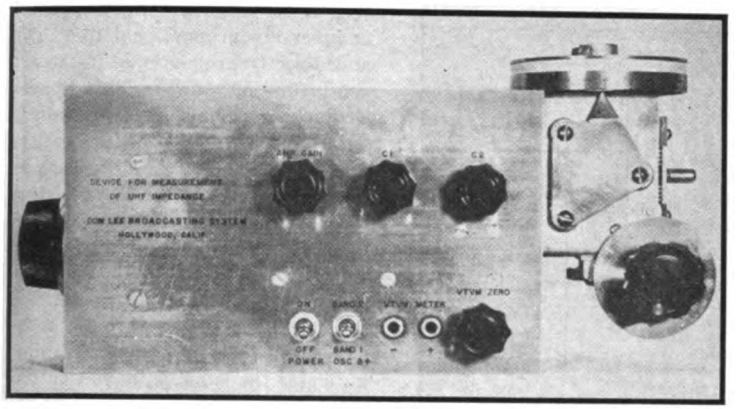

Unknown is connected directly to the calibrated capacitor at the right

MEASUREMENTS

Equipment for making impedance measurements in the range from 50 to 150 mc is described and its probable errors are analyzed. Construction and operation of the equipment and method of making measurements are explained

has been shown that unknown components across C_s affect circuit 1 independently.

It is important to connect the unknown directly to the terminals of C_s rather than to electrically equivalent points, to eliminate error which would be introduced by the inductance of the leads connecting circuit 2 to C_s. The method of tuning circuit 2 described below will show that the circuit inductive reactance is tuned out.

Care must be taken to maintain the Q of circuit 2 as high as possible because the principal assumption in this method of measurement is that the resistance of circuit 2 is negligible. Consideration of this resistance would make the measurements unnecessarily tedious. Experience has shown that very practical and useful results can be obtained with such an assumption.

The resistance R_1 of circuit 1 is used as a starting point for making measurements but it is not necessary to know the ohmic value. At one point in the tuning procedure, circuit 1 will be detuned from resonance until the square-law voltmeter indicates one-half the reading at resonance. This indicates a voltage 70.7 percent of maximum and shows that a reactance equal to R_1 has been added to circuit 1. This reactance will then be replaced by an equal reactance of opposite sign which can be accurately determined from C_s. The constant driving voltage is effectively in series with L_1 and C_1 because this circuit is driven by a pentode which is practically a constant-current generator. The inductive coupling between L_1 and L_2, which presents resistance and reactance components to circuit 1, need not be known.

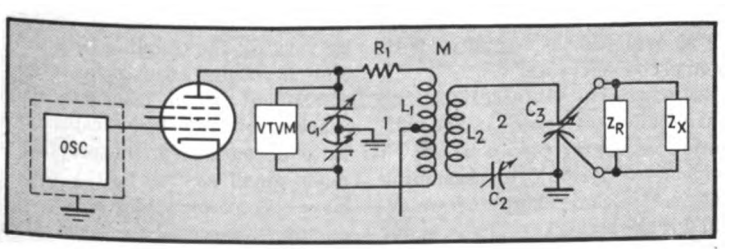

FIG. 1—The principle of measurement is that of a Q meter. The pentode prevents reaction of the measuring circuit on the oscillator and gives the generator a nearly infinite internal impedance

Measurement Procedure

In using the vhf impedance measuring circuit of Fig. 2, the following procedure is used:

1. Detune C_1 until it has no effect on the voltmeter and set the voltmeter to zero.
2. Set C_s to minimum so that $\Delta C_s = 0$.
3. Tune C_1 for maximum voltmeter reading and adjust the amplifier gain for a convenient reading, probably full scale. Circuit 2 is so far from resonance that it will have negligible effect on circuit 1 at this point.
4. Short C_s by inserting a strip of crimped copper between the plates. This must be done at the plates rather than across the terminals to avoid the error caused by

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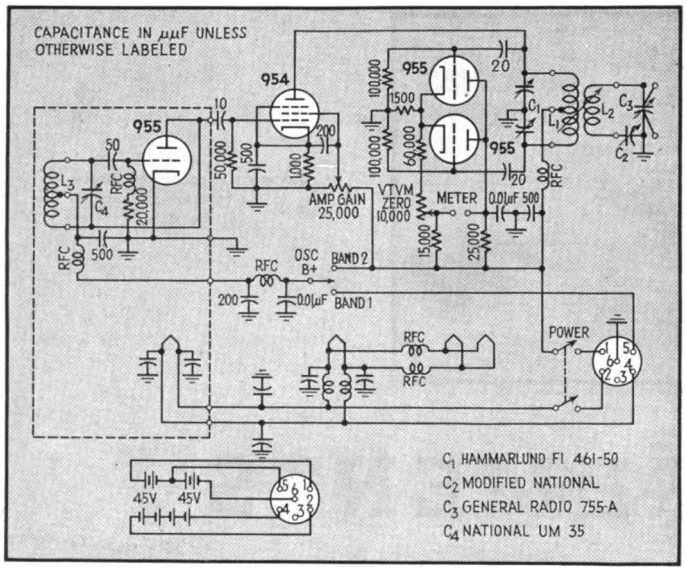

FIG. 2—A balanced, square-law vacuum-tube voltmeter is built into the instrument to measure the voltage across the resonant circuit

the inductance of a relatively long shorting bar across the terminals.

5. Tune C_2 for minimum voltage indication.

6. Remove the shorting strip and check C_1 for resonance.

7. Note the maximum voltmeter reading in dial units as V_1.

8. Detune circuit 1 by decreasing C_1 until the meter indicates one-half the maximum reading. At this point $X_{C1} = R_1$.

9. Retune circuit 1 to resonance by increasing C_2. This indicates that an impedance equal to R_1 has been presented to circuit 1 from circuit 2. Note (ΔC_2).

10. Add the unknown directly to the terminals of C_2.

11. Retune C_2 to cancel the added reactive component. Call the new setting of C_2 $(\Delta C_2')$. Note $(\Delta C_2')$ and the new voltmeter reading V_2.

12. $1/\omega(\Delta' C_2) - (\Delta C_2) = (\Delta' C_2)$ is the unknown reactance, where $(\Delta' C_2) = (\Delta C_2') - (\Delta C_2)$. From step 9 above

$$\frac{(\omega M)^2}{1/\omega(\Delta C_2)} = R_1 \qquad (\omega M)^2 = \frac{R_1}{\omega(\Delta C_2)}$$

The voltages developed across C_1 are inversely proportional to the effective circuit resistances so that

$$\frac{E_1}{E_2} = \frac{R_1 + \omega^2 M^2/R}{R_1} = 1 + \frac{1}{R\omega\,(\Delta C_2)}$$

$$R = \frac{1}{\left(\frac{E_1}{E^2} - 1\right)\omega\,(\Delta C_2)}$$

Let $P = (E_1/E_2) - 1$, and $V =$ voltmeter deflection in a square-law device, then $P = \sqrt{V_1/V_2} - 1$: $R = 1/P\omega(\Delta C_2)$: $X = 1/\omega(\Delta' C_2)$.

Analysis of Errors

From the above equations for R and X, we see that the accuracy of the measurements depends on a knowledge of frequency, (ΔC_2), and the voltage ratio used to find P. For greatest convenience in using an instrument of this type, it is necessary that the source of frequency be an integral part of the unit. The oscillator shown was calibrated with a heterodyne frequency meter, the fundamentals of which were referred to a frequency standard. Tuning circuit 1 through resonance may cause a frequency change of about 0.002 percent. It is safe to assume that errors in frequency will be negligible as compared with other probable errors.

By means of differentials, the relative effect of errors in the calibration or use of C_2 can be shown from $X = 1/\omega(\Delta' C_2)$. Assuming that $\Delta\omega = 0$, and taking logs we obtain $\log X = \log 1 - \log\omega - \log(\Delta' C_2)$; and differentiating obtain $dX/X = -d(\Delta' C_2)/(\Delta' C_2)$.

This result shows that the relative error in measuring reactance is inversely proportional to $(\Delta' C_2)$ and directly proportional to the error in finding $(\Delta' C_2)$. This is particularly serious for large inductances and small capacities because $(\Delta' C_2)$ is equal to the difference in the two settings of C_2. The resistive component of the unknown lowers the Q of the circuit so that the exact setting of this capacitor for resonance is more difficult. Sometimes it is better to tune through resonance until the voltmeter reading indicates the same point but on the other side of the resonance curve. Then one-half of the change in C_2 will be required $(\Delta' C_2)$.

The measurement of the resistive component involves the square root of the voltage ratio and also (ΔC_2) as the principal causes of error because again these errors will probably be large compared to the error in frequency. It is doubtful that C_2 can be set within about 2 or 3 percent because of the broadness of resonance.

The relative error in finding R which results from error in the voltage ratio is more easily predicted by considering the error in finding P. Let V_1 and V_2 be the meter deflections in any units and assume V_1 constant as the starting point, then $P = \sqrt{V_1/V_2} - 1$, taking logs; $\log P = \log(\sqrt{V_1/V_2} - 1)$, and differentiating

$$\frac{dP}{P} = -\frac{\left(\frac{1}{2V_2}\right)\sqrt{\frac{V_1}{V_2}}}{\sqrt{\frac{V_1}{V_2}} - 1} dV_2 =$$

$$-\left[\frac{1}{2V_2\left(1 - \sqrt{\frac{V_2}{V_1}}\right)}\right] dV_2$$

The factor inclosed in brackets is plotted as a function of V_2 in Fig. 3. This curve indicates the range through which V_2 may be read for minimum error. The values of V_2 and (ΔC_2) are interdependent and can be adjusted toward optimum by varying the coupling between L_1 and L_2. This adjustment also is convenient in the measurement of reactance. If a large capacitance is to be measured, the coupling is made small so that (ΔC_2) will be large. Conversely, for a large inductance, the coupling is made close. This adjustment effectively doubles the useful range of C_2. Errors in determining P or (ΔC_2) affect R

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in just the same manner as an error in ($\Delta' C_s$) affects the measured value of X. Of course, the errors can tend to cancel or to accumulate, depending on the relative sign of the differential value.

Description of Unit

If the power leads are filtered, no r-f will get to L_1 except through the pentode amplifier which approximates a constant-current generator. A butterfly circuit[4] oscillator is an ideal source of power for such a device because of its range, small size and simplicity.

The upper frequency limit of this particular unit is 150 mc. This limit is determined by the necessary inductance of the leads to C_s because the terminals of C_s must be available for connecting the unknown. L_2 must be large enough to couple sufficiently with L_1.

The square-law vtvm is best checked by plotting the square root of the meter deflection as a function of the applied voltage. If the meter response is square-law, this plot gives a straight line.

In use, the balance of the L_1C_1 circuit can be conveniently checked by tuning C_1 to resonance and then touching each stator section of C_1 in succession. The voltmeter reading should drop to nearly zero in each case. Small amounts of unbalance can sometimes be compensated by adjusting the center-tap by-pass capacitor. Choice of tubes or of bias operating point is relatively unimportant.

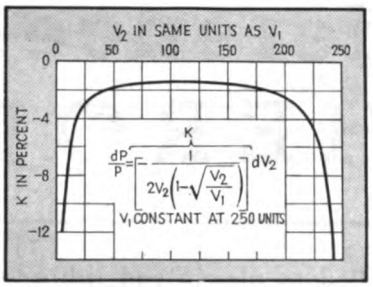

FIG. 3—Adjust coupling between circuits 1 and 2 of Fig. 1 to keep V_2 within the range of least relative error K which can be introduced by inaccuracies in reading voltages when measuring resistances

Typical Measurements

In making any measurement, it is comforting to be able to make it by at least two radically different methods. Because the range of this instrument overlaps the upper limit of the General Radio 916-A r-f bridge, a complete comparison of the two methods at 50 mc was possible. The average difference for random measurements was within five percent and in many cases less than two percent.

Figure 4 shows the results of a group of measurements to determine the characteristic impedance[5] of a 50-foot length of concentric line. The open-circuit and short-circuit reactances of the line are plotted as a function of frequency without regard to sign.

Figure 5 gives the characteristics of a dipole fed with a length of EO1 cable. As this is a balanced impedance and the instrument is an unbalanced device, the measurement is tedious but the curves indicate the results that can be expected and demonstrate the consistency of the measurements. The value of about 76 ohms resistance at resonance is reasonable.

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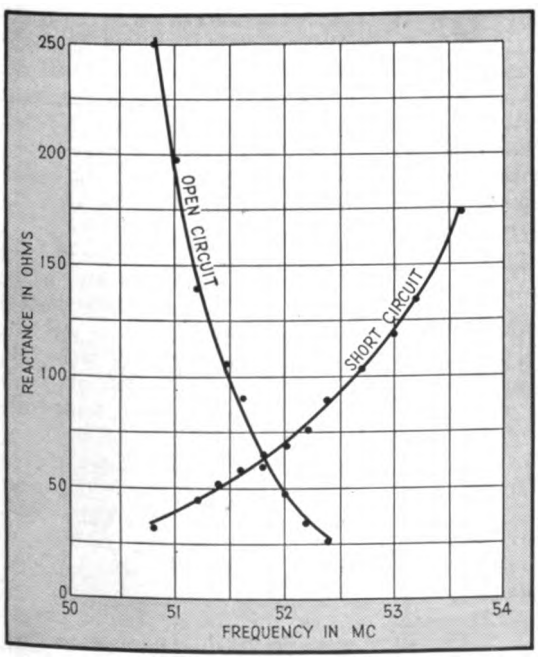

FIG. 4—Measurement of coaxial-line reactance made with the instrument

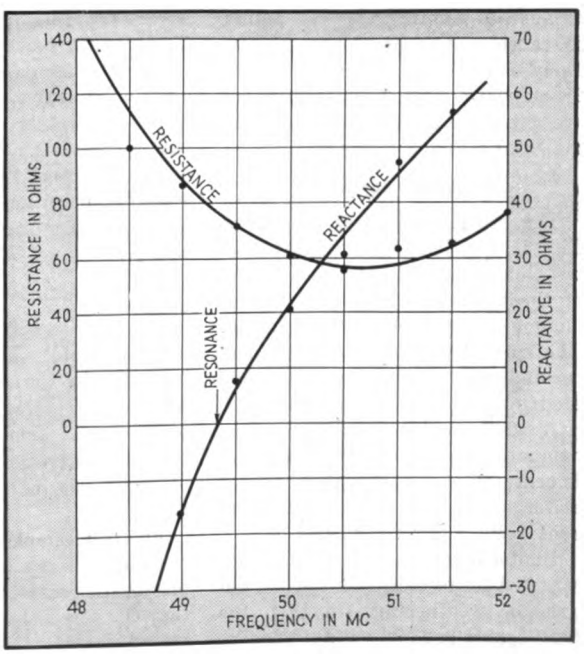

FIG. 5—Impedance of a dipole antenna as measured with the test instrument

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Interference-Free WEATHEROMETER

Accelerated weathering is applied to plastic and rubber materials and measured with photoelectric equipment. Automatic cycling of wetting and irradiation is provided and no radio interference is caused. The action is about ten times faster than outdoor exposure

THE weatherometer to be described was developed to furnish accelerated weathering for testing components of aircraft radio equipment. Such tests are made on plastic and rubber material and nameplates. The device simulates the conditions of rain and sunlight and provides two hours of wetting, two hours of irradiation, two more hours of wetting and 18 hours of irradiation as prescribed in Federal and Navy aeronautical specifications. This is continued through 10 cycles or 240 hours.

The weathering conditions are provided by two infrared lamps for heat, ultraviolet lamps for irradiation, and a sprinkler for wetting. Three sunlight lamps were used for the ultraviolet source because a flaming arc was found to cause radio interference. The likely changes in the physical condition of the samples after testing are crazing, discoloration, blooming, and warping.

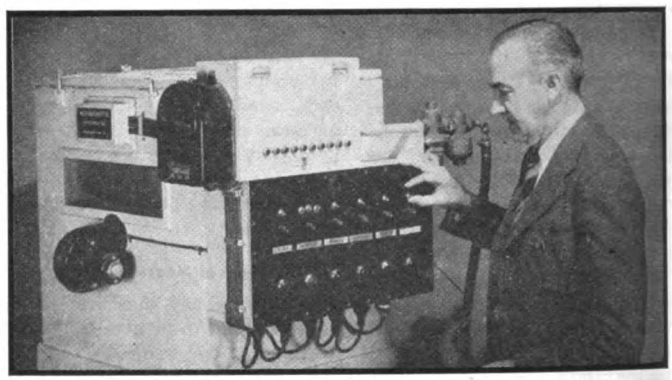

FIG. 1—Interference-free weatherometer for accelerated weathering tests of components

Weathering Equipment

The complete unit is shown in Fig. 1. The lamps are mounted in an aluminum reflector the length of the cabinet, with each infrared lamp between two sunlight lamps. The sprinkler is a brass pipe perforated with small holes and operated by a solenoid-type valve.

A wire rack is fitted inside the cabinet so that the sample material is centered at a vertex point where water spray, light rays, and air current from a blower meet.

Photoelectric equipment was constructed for measurement of the degree of weathering. In this, the light source is a six-volt automobile-type bulb mounted in front of a reflector and lighted from a storage battery. A Weston Photronic cell with a Viscor filter is connected to an ammeter with a 100-μa range. A variable resistor is used to adjust the light intensity.

The light-source is mounted behind a partition equipped with a one-inch circular aperture in one end of the box. In the other end of the box and 18 inches away is a similar partition equipped with a one-inch aperture in front of the cell.

Calibration

For test samples, strips of cellulose nitrate material 0.125 inch in thickness were subjected to the weathering cycle and outdoor exposure. The amount of discoloration was measured on exposed samples each day by light transmission methods.

The test samples were cleaned of dust and grease and measured by placing in front of the aperture at the cell. The cell receives the undeviated fraction of the light and part of the scattered light which is not deflected at angles greater than about 90 degrees. The total light transmission of the test sample is the fraction of the original light received by the cell which continues to reach the sensitive element. When the reading taken without the test sample is 100 μa, the reading taken with the sample in front of the Photronic cell aperture gives the percentage of total light transmitted.

Manual Controls

On the black Bakelite panel shown in Fig. 1 are eight toggle switches. The switch on the left side of the panel operates the blower, and the cluster of three switches controls the three sunlight lamps. A choice of one, two, or three sunlight lamps can be had. The next two switches to the right control the infrared lamps. Another switch operates the solenoid valve for the sprinkler.

The heart of the automatic control is the rotary selector switch shown in Fig. 2. This was obtained from a pin-ball machine and has 36 contacts of which 25 are used. This

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By W. B. RITCHIE AGNEW
Chemical Engineer
Aircraft Radio Laboratories
Wright Field, Dayton, Ohio

selector switch (*A* in the circuit of Fig. 3) is operated by two solenoid magnets, one magnet operating a ratchet-wheel and the other solenoid controlling the kick-back.

Weather Sequence

A cardboard dial is fastened to the shaft of this switch and is numbered from 1 to 24, denoting hours. The first two segments are also marked RAIN, the next two are marked SUNSHINE, the fifth and sixth contacts are marked RAIN and the remaining 18 are marked SUNSHINE. The 25th contact operates the kick-back solenoid which releases the ratchet and allows a spring to return the ratchet-wheel to its starting position. At the same time, the electromagnet in another selector switch of the telephone type (*B* in Fig. 3) which is mounted on the lid of the automatic control is energized.

To start the automatic cycling device, the switch on the extreme right of the manual control panel is

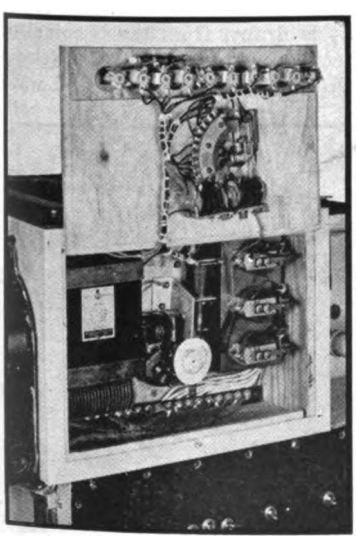

FIG. 2—The control panel of the weatherometer contains switches, fuses, and pilot lights. The rotary selector switch came from a pin-ball machine

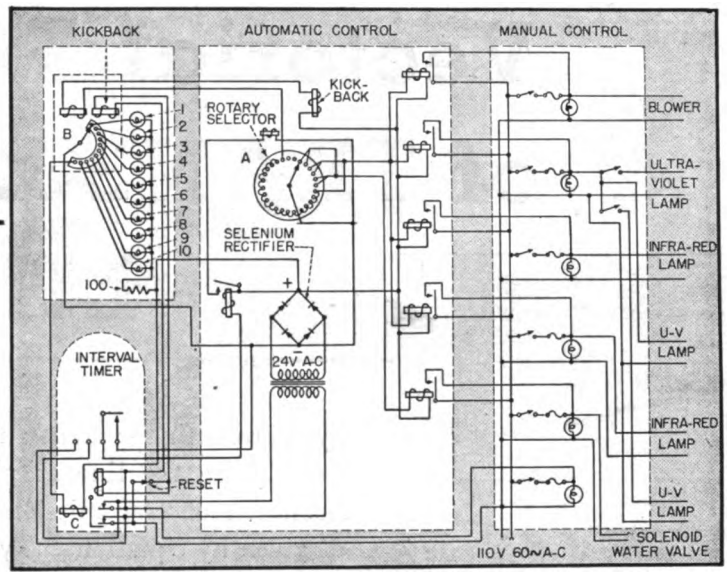

FIG. 3—Relay and switching circuits of the weatherometer

operated. With all switches in their off positions, the automatic control switch starts the Telechron clock of the interval timer.

A pushbutton in the interval timer is used for a momentary impulse to lock relay *C* into place. With this relay locked and the automatic control switch on, the clock runs. The dial on the shaft is divided into 60 segments denoting minutes. A glance at the two dials shows the number of hours and minutes of any 24-hour cycle.

The relay which closes the circuit between the contacts of the solenoid valve switch is closed due to the position of selector switch *A* which is on its number 1 contact. Number 1 panel lamp of the ten shown on the front of the automatic cycling device is lighted denoting the first 24-hour cycle or day. Now at a glance we can add days to our computation of time of weathering or calculate the time necessary to finish the required 10 cycles of 24 hours. At the end of the 10th cycle, the selector switch *B* makes the 11th contact which energizes the electromagnet which unlocks relay *C*. This opens the a-c input and completely shuts the weatherometer down.

Interval Timer

The interval timer makes a momentary contact of its built-in switch every hour. This impulse energizes the solenoid magnet of the rotary selector switch and, at the end of the first hour, the energized solenoid moves the ratchet-wheel contact to the second contact. This contact also connects to the solenoid-valve relay, and consequently the rain part of the cycle remains on.

At the next impulse from the interval timer, the selector switch moves up another contact; this breaks the solenoid-valve circuit and cuts in the relays controlling the blower, sunlight lamps and both infrared lamps. The weatherometer is now on the sunshine part of the weathering cycle. The interval timer continues to operate the selector switch through its controlling relay every hour of the 24-hour cycle.

When the 25th contact is made, the kick-back solenoid of the rotary switch *A* returns it to contact number 1 to begin the second cycle. This 25th contact also energizes the ratchet-wheel magnet of selector switch *B* and moves the switch arm to contact number 2, turning off the first light of the 10 denoting the number of cycles or days and turning on panel light number 2. This indicates that the first 24-hour cycle is completed and the second cycle is starting.

The acceleration factor of the interference-free weatherometer was found to be between 10 and 11 times greater than results obtained from outdoor exposure.

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Vectorial Treatment of TRANSMISSION LINES

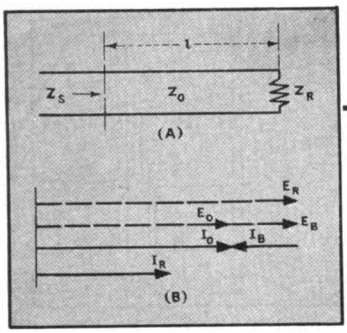

FIG. 1—(A) Transmission line showing relation of point, surge, and load impedances, and (B) currents and voltages at load for a load of $2Z_0$

By representing current and voltage as vectors, and distance along the line as phase displacement, a clearer treatment of transmission lines is obtained than that given by equations. Typical problems are solved

By J. P. SHANKLIN

Assistant Project Engineer, Bendix Radio Division of Bendix Aviation Corp. Baltimore, Md.

MOST TRANSMISSION LINE problems can be solved by vectors. The use of vectors makes the action of the line clear and allows visualizations which would otherwise be difficult.

Conditions at Load

Standing waves on a transmission line are caused by two waves, the incident and the reflected waves, traveling in opposite directions. At certain points the two voltages add and at certain other points they subtract. In Fig. 1A let $Z_R = 2Z_0/0°$. A 2:1 standing wave ratio will be caused by the mismatch, the maximum value of which will be $E_0 + E_R$ and the minimum value $E_0 - E_R$ and $E_0 + E_R = 2\ (E_0 - E_R)$ or

$$E_0/E_R = 3 \qquad (1)$$

where the symbols are as defined in Table I.

The load is resistive and higher than the line impedance, therefore there is a high of the standing wave at the load or

$$E_R = E_0 + E_R \qquad (2)$$

The voltage vectors of Fig. 1B may be drawn from Eq. (1) and (2).

As to the currents involved, the incident current I_0 is considered to be in phase with the incident voltage E_0 but the reflected current I_R is considered to be 180° out of phase with the reflected voltage E_R. This is because of the sense of direction of flow which has been chosen.

The reflected wave may be considered as negative power because it is returning to the generator. The voltages are considered to have the same direction sense because both are measured across the line. A scale for the currents is chosen which will make the vectors I_0 equal E_0 and I_R equal E_R in length. The ratio of the scales used for voltage and current is dependent on the line surge impedance Z_0 according to the relation

$$\text{Scale Ratio} = Z_0 = E_0/I_0 = E_R/I_R \qquad (3)$$

Conditions Away From Load

Figure 2A is a vector diagram of the line voltages and currents for the same load as in Fig. 1 but where l equals 45 electrical degrees of line.

A single vector is used to represent E_0 and I_0. This vector is advanced 45° (counterclockwise) from the position of E_0 and I_0 in Fig. 1B because the incident wave will reach this point earlier. The vector E_R is drawn from the terminal of vector E_0, I_0 and retarded (clockwise) 45° since the reflected wave

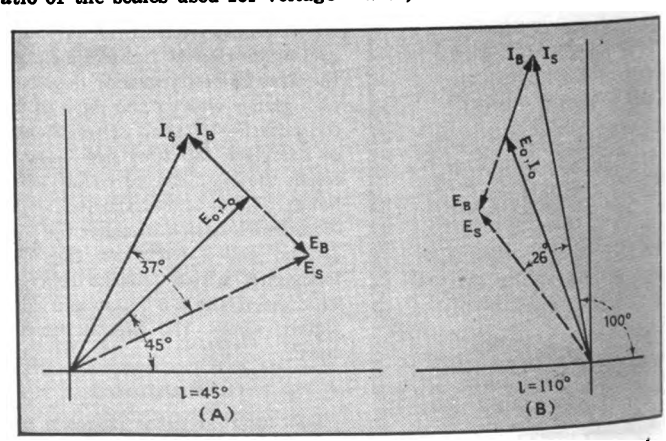

FIG. 2—Current and voltage relations for a line terminated in a resistance of $2Z_0$. (A) 45 electrical degrees from the load, and (B) 110 electrical degrees from the load

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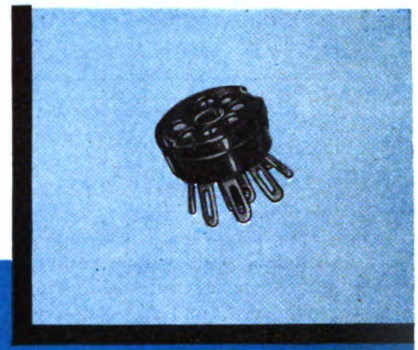

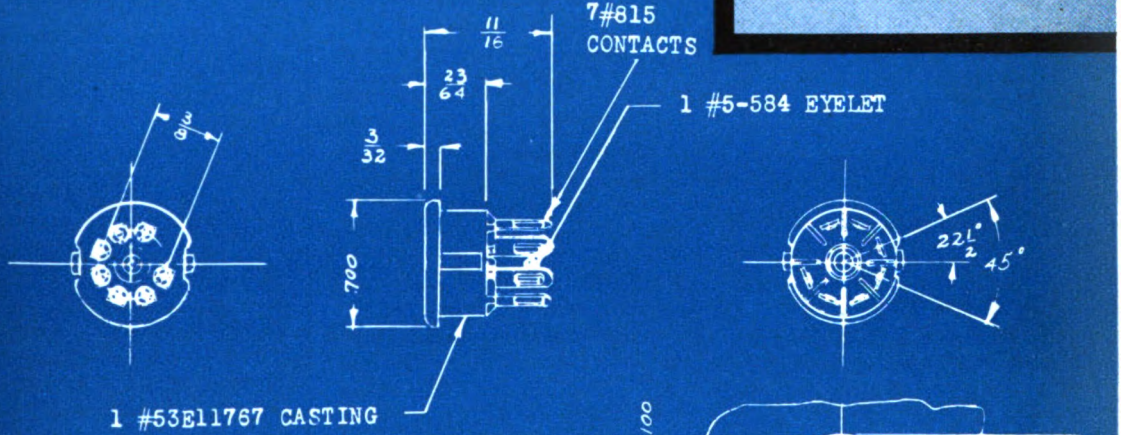

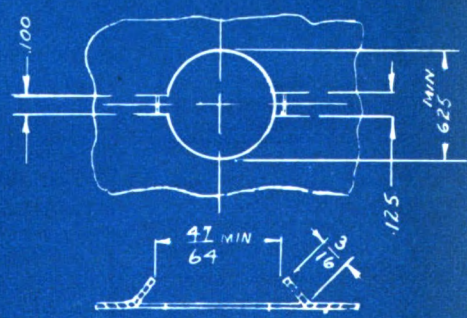

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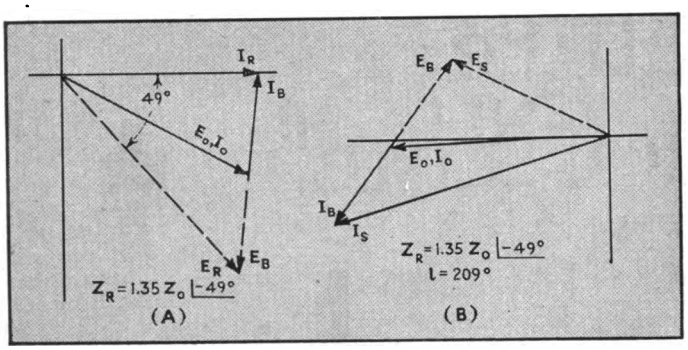

FIG. 3—Vectorial representations of conditions at a complex load (A), and some distance from it (B)

reaches this point later.

The vector sum of E_o and E_R results in the line voltage vector E_R. The vector I_R is drawn as before, 180° out of phase with E_R. The vector sum of I_o and I_R results in the line current vector I_R. This diagram reveals that

$$Z_S = E_S/I_S = Z_o \angle -37°$$

and also that the phase angle of E_S and I_S relative to E_R and I_R can be measured.

Figure 2B is the vector diagram when l is 110° and yields the following data

$Z_S = 0.608\ Z/26°$.

I_S is 100° ahead of load current I_R.

E_S is 126° ahead of load voltage E_R.

Figure 3A is the vector diagram at a complex load $1.35\ Z_o \angle -49°$.

TABLE I
DEFINITION OF SYMBOLS USED IN THE TEXT

E_o, I_o	—Incident voltage and current at the load
E_R, I_R	—Voltage and current across load Z_R
E_B, I_B	—Voltage and current reflected by the load
E_S, I_S	—Voltage and current a distance l from the load toward the generator
Z_o	—Surge impedance of the transmission line
Z_R	—Impedance of the terminating load
Z_S	—Impedance at a point on the transmission line
l	—Distance along transmission line measured in electrical degrees from the load toward the generator

For other symbols used in text, see circuit diagrams

First the vectors I_R and E_R are drawn, making E_R equal 1.35 I_R and current leading 49°. I_R has been taken on the zero or reference axis although this is immaterial.

Connect the terminals of I_R and E_R and plot a point in the center of this line. This point is the terminal of the E_o, I_o vector. I_R can be seen to be the vector sum of I_o and I_B, and E_R the vector sum of E_o and E_B. The E_o, I_o and E_B, I_B vectors have now been determined so that the vector diagram for any point on the line may be drawn.

Figure 3B is the vector diagram 209° away from the load. The E_o, I_o vector has been rotated 209° counterclockwise from its position in Fig. 3A and E_R and I_R have been rotated clockwise 209° from their positions in Fig. 3A.

Antenna Feeding

A problem sometimes encountered in a high-frequency array is to feed three dipoles in phase, the center dipole to be fed 1.5 times the current of the outer dipoles. This problem is similar to that of feeding the towers of a broadcast transmitter at the necessary current amplitudes and phases to develop a required radiation pattern.

The feeding system is shown in Fig. 4A. Because the end antennas were similar, they were combined reducing the circuit to that of Fig. 4B and impedances expressed in terms of the feed line impedances. Fig. 4C is the vector diagram at the Z_1 load and Fig. 3A the vector diagram at the Z_2 load. Note that the two load current vectors are drawn to satisfy the antenna requirements. That is, they are in phase, and the length of I_R Fig. 4C is scaled two units representing current in both end dipoles, and I_R of Fig. 3A is scaled 1.5 units.

There are three requirements to be met: (1) dipole currents must be in phase, (2) dipole currents must be in a 1.5 to 1 amplitude ratio, and (3) a resistive 50-ohm load must be presented to the 50-ohm line. Using the two variables l_1 and l_2 it is probable that any two of these requirements can be satisfied. The first two have been chosen because they must be satisfied before the lines are joined. The loads must

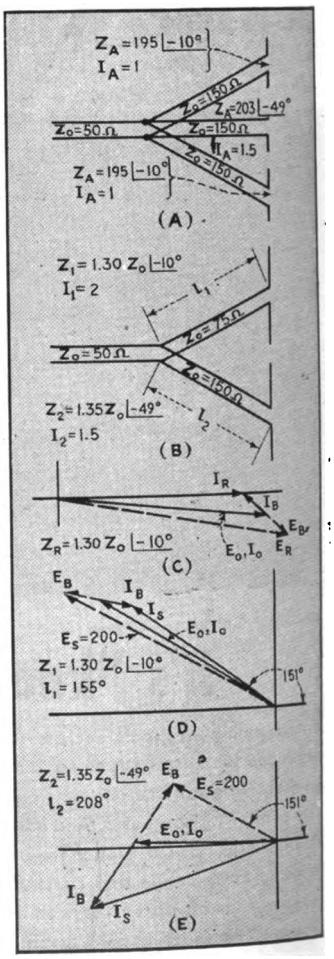

FIG. 4—Determination of feeding condition for a three-element array can be made vectorially. The given conditions are shown at (A), which can be simplified to (B) from which vectors at the upper antenna can be plotted (C). Vectors for the lower equivalent antenna are as at (A) in Fig. 3. The angular distance at which voltages on antenna feed lines are in phase is determined from (D) and (E)

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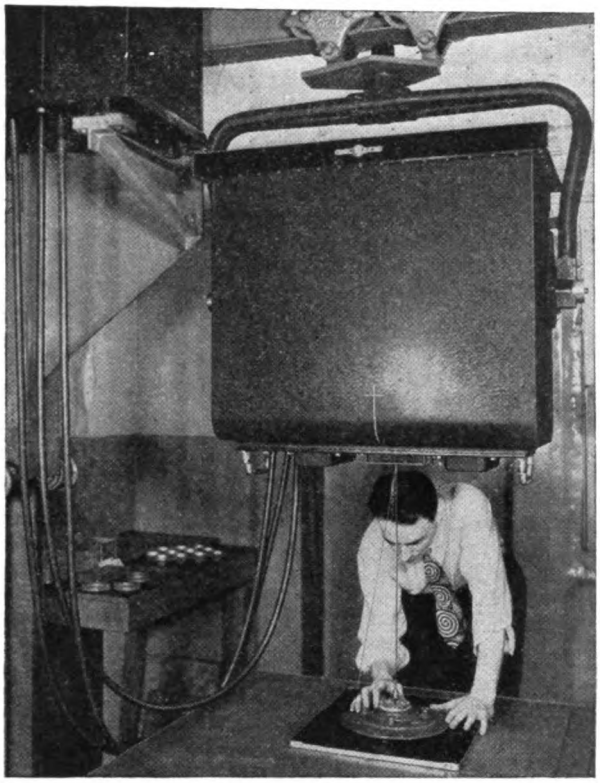

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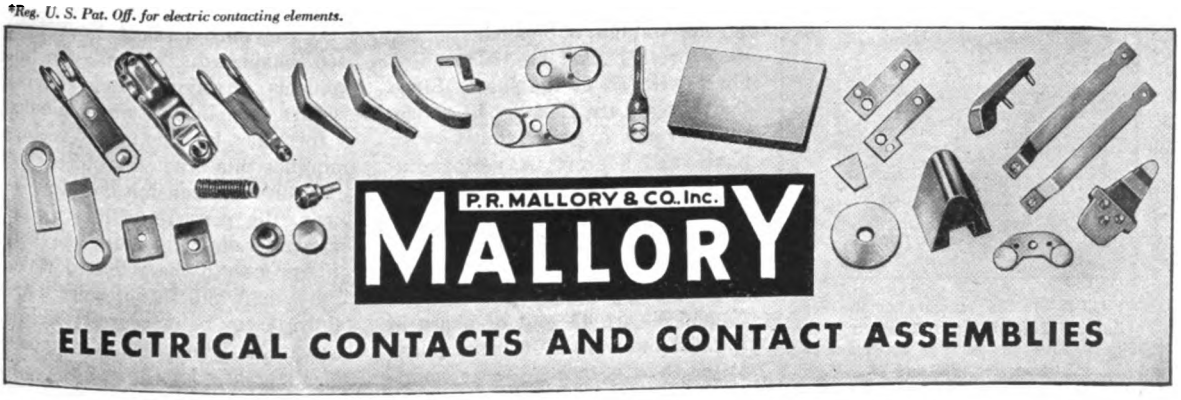

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give enough reflection to cause sufficient impedance variations along the lines to make a solution possible.

It is then necessary, by drawing trial vector diagrams for different lengths of l_1 and l_2, to find the lengths which will fill the first two requirements. Because the loads do not greatly mismatch their lines, lengths near even $\lambda/2$ multiples were tried in hopes of also partially satisfying requirement (3). Also, it is apparent that l_2 must be longer than l_1 because the current in Z_2 is to lead the current in Z_1 by 39° and must therefore be retarded.

Figure 4D is the solution. In order to connect the two lines together their voltages must be equal and in phase. The apparent difference in amplitude of the E_s voltages in Fig. 4D and E is due to 2:1 ratio of scales used for the 150 and 75-ohm lines. The current scales, however, are equal.

Impedance Matching

Figure 5 is the vector diagram of the input currents and voltage at the juncture of l_1 and l_2. The currents I_1 and I_2 in the two lines are added vectorially to give the 50-ohm line current I_s. The E_s vector is the same vector as E_s of Fig. 4D and 4E except that the voltage scale has been changed to conform to a 50-ohm line. The input impedance of 1.1 Z_o $/-21.5°$ would be considered satisfactory for most high-frequency work.

The impedance 55 ohms $/-21.5°$ may be matched to the 50-ohm line by the short-stub corrector shown in Fig. 6A. First draw the vector diagram of Fig. 6B at the load. As I_R is leading E_R an inductive or lagging current will be needed to bring

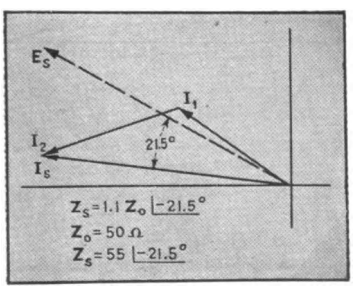

FIG. 5—At the juncture of the feed lines of Fig. 4B the voltages and currents have this relation as determined from Fig. 4D and 4E

them into phase. Also, the length of the I_s vector must equal the E_s vector to represent a 50-ohm load.

Next draw the diagram of Fig. 6C. Draw the E_o, I_o vector of Fig. 6B at any angle (180° in Fig. 6C). From the terminal of E_o, I_o strike an arc of radius equal to E_s. Draw the vectors E_s and E_R, making the angle between them 90°. Draw I_R and I_s. I_o will then represent the inductive current to be drawn by the correcting stub. Note that it lags 90° behind the voltage E_s across the stub.

The 50-ohm line current I_{50} is the vector sum of I_o and the input current I_R to line l_1. The angle between E_o and E_R in Fig. 6B is 105.5° and the angle between E_o and E_R in Fig. 6C is 79°. The difference of 26.5° is caused by their rotation in traveling over the length of line l_1. The electrical length of l_1 will be half this amount or 13.25° because the vectors rotate in opposite directions. If desired, Fig. 6C may be redrawn in proper angular reference to the preceding diagrams. This results in Fig. 6D which is the input diagram for Z_R = 1.1 Z_o $/-21.5°$ and l_1 = 13.25°.

Figure 6C could have been drawn by calculating the magnitude of E_s first, and drawing E_R at right angles to E_s. The total power on the line will be the same at all points, therefore in Fig. 6B $P = E_R I_R \cos 21.5°$, or scaling E_R and I_R, $P = 200 \times 3.6 \times 0.930 = 670$. In Fig. 6C, $P = E_s^2/Z_o$ or $670 = E_s^2/50$, thus $E_s = 183$.

Stub Length

In determining the length of the stub l_2 of Fig. 6A, first consider the characteristics of a shorted line. There will be 100 percent reflection at the short, therefore E_R will equal E_o and I_R will equal I_o. There can be no voltage across the short, therefore E_R must be 180° out of phase with E_o at the short. Since the voltages are 180° out of phase, the currents I_o and I_R must be in phase and adding. A vector diagram could be drawn representing these conditions at the short.

Now draw Fig. 6E, the vector diagram for the input to the stub. I_o and E_s are copied from Fig. 6D. E_o and E_R are 45° out of phase in Fig. 6E and were 180° out of phase at the short. Since E_o turns counterclockwise and E_R clockwise, to have reached their position in Fig. 6E they must have moved in relation to each other by the larger angle between them, or 135°. Therefore l_2 of Fig. 6A must then be half this long or 67.5°.

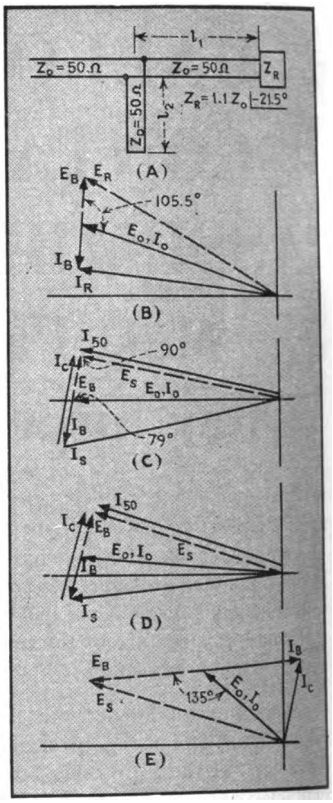

FIG. 6—To match the transmission and feed lines, a shorted stub (A) is required. Conditions at the load are shown at (B), and the inductive current to be drawn by the stub is determined from (C). (D) is (C) reoriented to agree with previous vector positions. (E) represents the input to the stub from which stub length is determined

Lines With Loss

So far only lossless lines have been considered. Transmission line problems involving lines having loss are complicated when handled by formulas, but the use of vectors simplifies this type of problem.

Because a transmission line is linear, the percentage loss to the incident wave will equal the percentage loss to the reflected wave. If the input and output powers are known or can be measured, the line loss can be determined, and apportioned for any length line.

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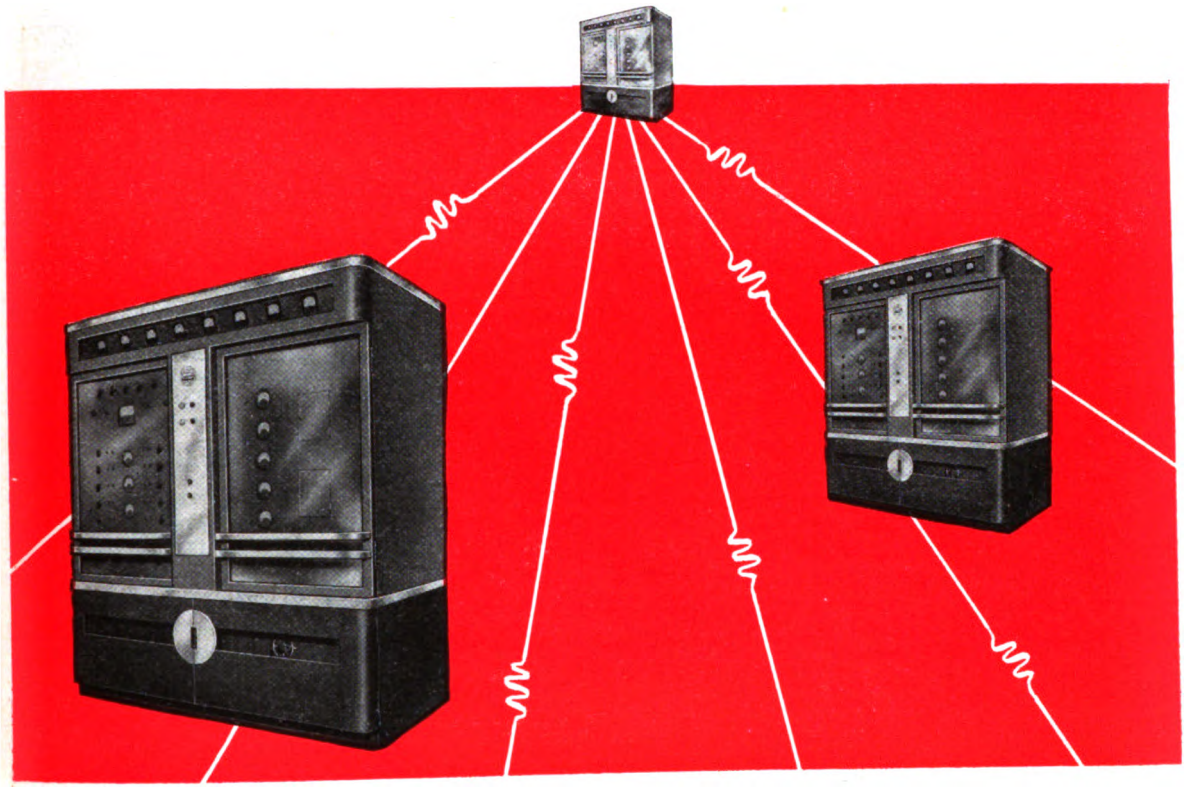

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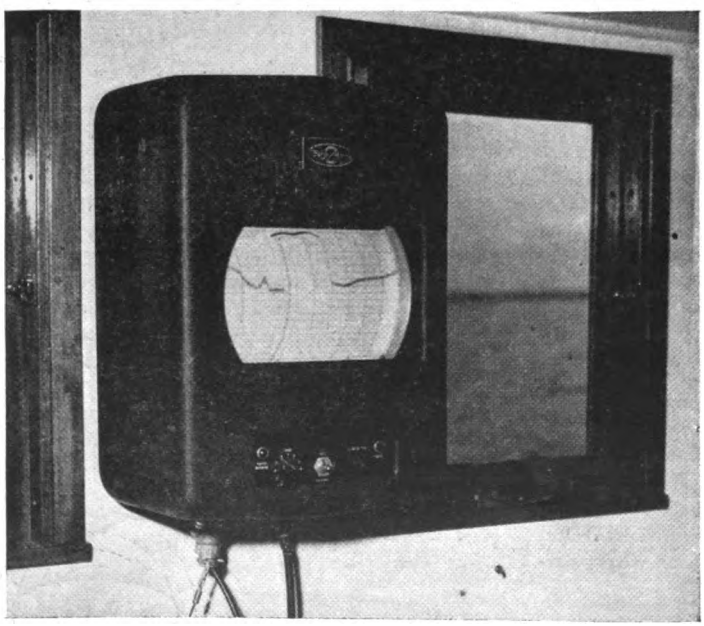
BENDIX-MARINE division of Bendix Aviation, Baltimore 4, Md., announces it will soon produce in volume a supersonic depth recorder for small boats and pleasure craft. The unit is designed to help make coastal navigation safer in fog and night and to locate fishing banks and schools of fish. Five vacuum tubes are utilized in the unit. Essentially there are two main units in the depth sounder; the recorder and the underwater transducer.

The cabinet of the recorder unit mounts compactly in a ruggedly built, splashproof aluminum case which measures 10 x 16 x 21¾ in. It houses the graphic recording mechanism, signal sender, echo amplifier, synchronous driving motor and power pack. Total weight is 90 lb. The underwater unit is a special crystal transducer which weighs 22 lb. and measures 7 in. in diameter. The same transmitter which projects supersonic signals downward from the ship's bottom, also acts as the echo receiver.



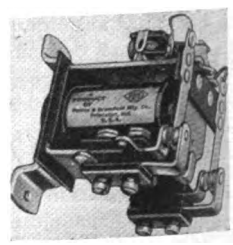
The recorder is shown mounted in the wheel house of a sea-going laboratory ship. Recordings made on Flushing Bay, N. Y. during a recent demonstration are shown here on the chart in the illustration. Lines at left and right show the depth of water in feet; the line at topcenter, the depth in fathoms. By changing the speed of the graphic recorder readings can be obtained either in feet or in fathoms

The device bounces a high-frequency signal off the bottom of the sea and draws a permanent and accurate picture of the ocean bottom. The design of the recorder minimizes maintenance costs. No special skill is required to maintain the unit.

This view of the sea-going laboratory ship shows the outboard rigging (on the starboard side) which makes possible the use of the depth sounder developed as a completely portable unit

Plate Circuit Relay

STANDARD TYPE PLATE circuit relays (LMR Series) are available in both single and double pole contact arrangements. Single pole relays measure 2¼ x 2⅜ x 1⅜ in. Double pole types measure 2¼ x 2⅜ x 2⅛ in. Mounting dimensions are 2 tapped holes 6-32 thread, 1⅞-in. center to center. Relays are constructed with extra large coils to make them sensitive and to give good contact pressure at low current values. Standard adjustment is approximately



0.1 w for sp types, and 0.2 w for the dp types, with lower values available if necessary. Unless specified, contacts are of ⅛-in. fine silver. Coils are available in all resistances up to 10,000 ohms. Contact arrangements available include spdt; spst normally open; spst, normally closed; dpdt dpst, normally open; and dpst, normally closed. Potter & Brumfield Mfg. Co., Inc., 214 Linden Ave., Princeton, Ind.

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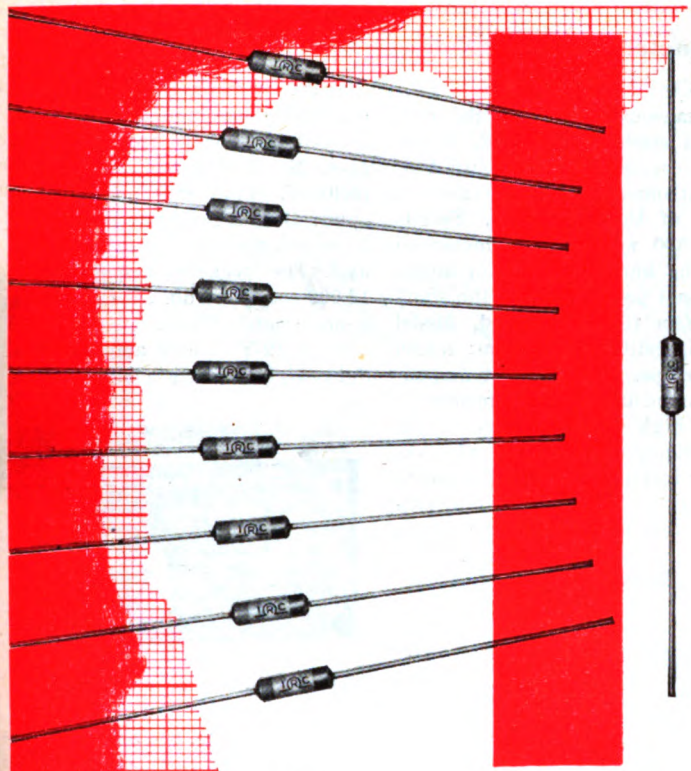

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IRC TYPE BWS
¼ WATT INSULATED
WIRE WOUND RESIS

Here's a brand new IRC resistor that until a few weeks ago was very "hush-hush" except to a few selected laboratories and prime contractors engaged in development and manufacture of VT proximity fuzes. Production on this small, efficient unit, in the last several months before V-J day, mounted to amazing figures to keep pace with the advancing victory tempo. Now this same high quality resistor is available in quantity to help solve many a "small space" resistance problem for you. Rated a full quarter watt, small 'round as a match stick and but 13/32" in length, this sturdy insulated wire wound can be depended upon for "Preferred Performance." For technical data refer to IRC Engineering Bulletin No.3, available on request from *Dept. 1-L.*

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IRC makes more types of resistance units, in more shapes, for more applications, than any other manufacturer in the world.

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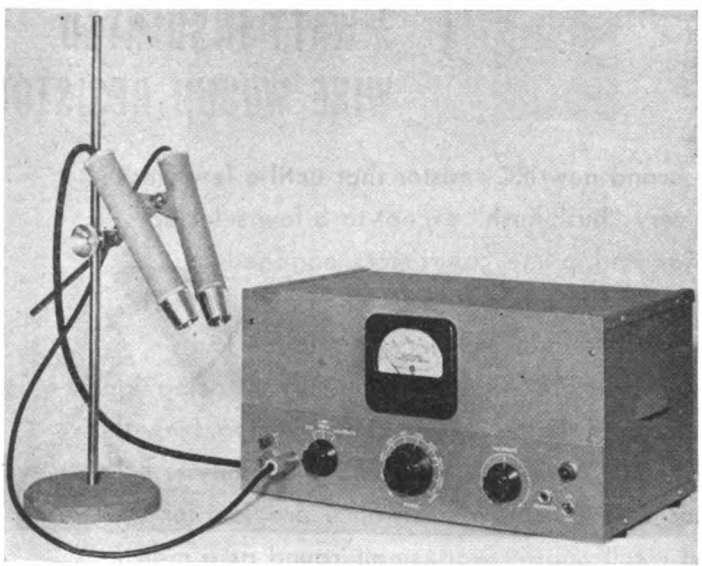
Electronic Tachometers

NEWEST ADDITIONS to Hewlett-Packard Company's (Palo Alto, Calif.) group of laboratory and production testing instruments are hp models 505A and 505B electronic tachometers. The tachometer (consisting of a photocell and light source hook-up) used in conjunction with an electronic frequency meter, is used to measure the speeds of moving parts over a range from about 300 rpm (5 rps) to 3,000,000 rpm (50 rps). The unit is capable of measuring very high speeds of rotating parts which have small energy, or which cannot be mechanically connected to any measuring device. Danger of making multiple or fractional errors are eliminated, and an instantaneous record of the continuous speed is provided. A recorder connected to the output of the instrument makes a permanent record of these readings. Speeds below 300 rpm can be measured with the unit by means of slight additional preparation of the shaft or surface to be measured. Model 505A is calibrated in rpm; model 505B in rps. Some suggested applications include measurements of small, high speed motors, ultracentrifuges, or the electronic frequency meter can be used alone to measure the frequency of alternating current at frequencies as high as 50 kc. A technical data sheet is available from the manufacturer.



Collins Radio Products

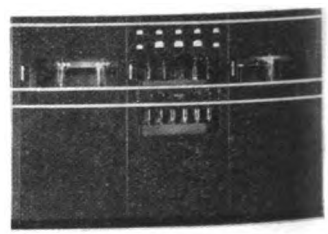
COLLINS RADIO CO., Cedar Rapids, Iowa, announces:

A new 4-channel high fidelity remote amplifier (type 12-Z) which embodies circuit refinements and component improvements. The unit weighs less than 35 lb, is easily and quickly placed in operation, and has self-contained power supplies, both a-c and d-c, the latter in the form of batteries. Front-access attenuators, provide easy maintenance. A master control is provided in addition to the individual control for each channel. A meter calibrated in v-u indicates the volume level, and also is used to measure operating voltages. Monitoring facilities are also included. Input impedance is 30/50 ohms. Output is 50 mw at less than 1 percent distortion into a 600-ohm load. The frequency response is 30-12,000 cps, ±1.0 db. Overall gain is approximately 95 db.

Type 12-Y remote amplifier is a lightweight, single channel, high

fidelity amplifier suitable for dance orchestra and newsroom pickup, sports broadcasts, and any other application where fast set-up is important. It weighs 7 lb in its carrying case, has three stages of amplification for a maximum gain of 84 db, a universal input, and 600-ohms output. The unit operates from 110 v, ac, 60 cps. Power supply is self-contained.

Type 21-A a-m broadcast transmitter for the 540-1600-kc range



has an audio frequency response curve flat from 30-10,000 cps, ± 1.5 db. Noise level is more than 60 db below 100 percent modulation. Distortion is less than 3 percent rms. The carrier frequency is maintained constant to within ± 10 cps. The transmitter carries full FCC approval for 5000 and 1000 w high-fidelity broadcast operation. Power output of 1 kw can be obtained instantaneously by operating a switch which controls plate voltages.

Type 300-G a-m broadcast transmitter utilizes high level class B modulation. It is rated 250/100 w.

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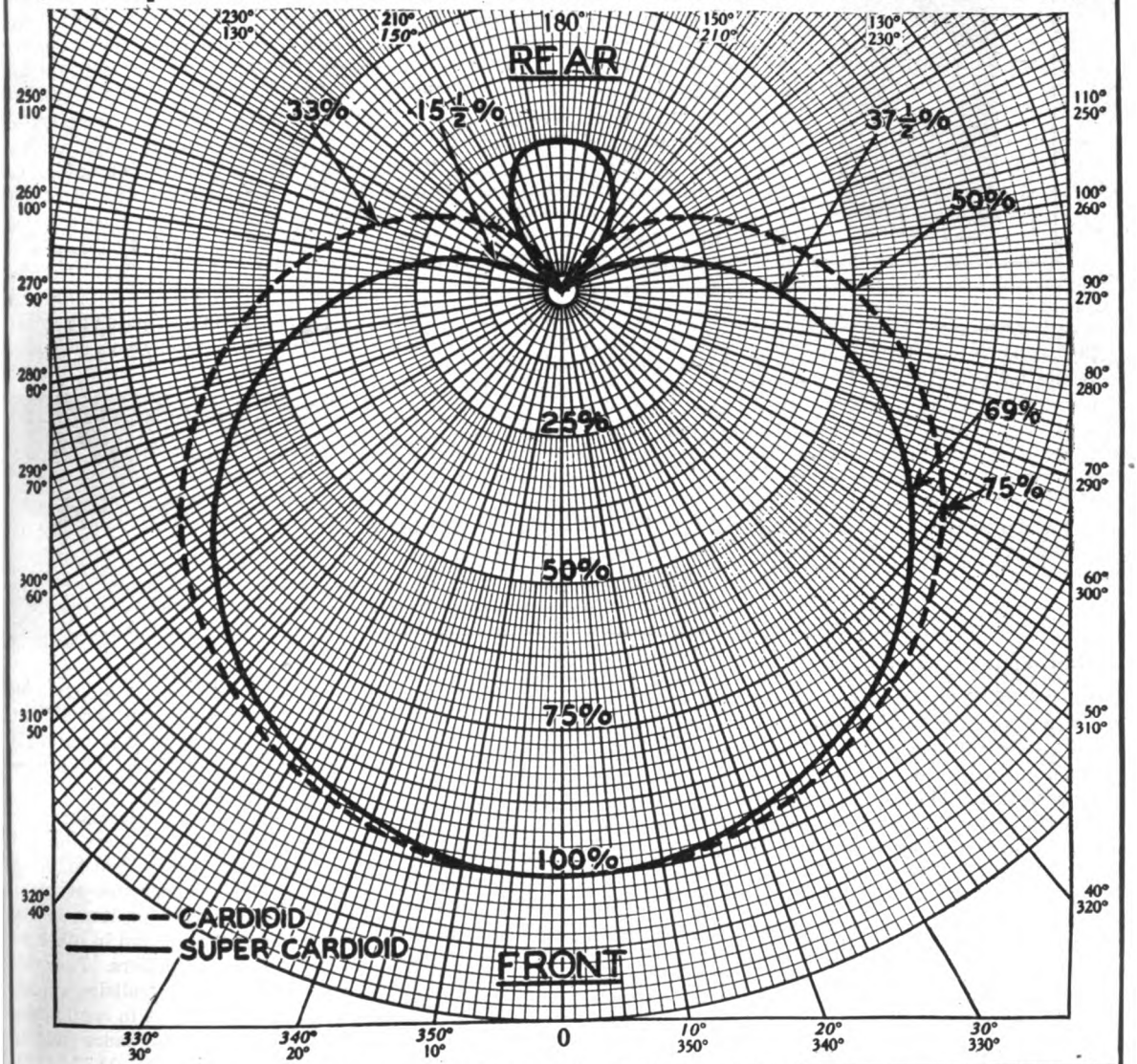
. . . Comparative Graph Proves SHURE Super-Cardioid Microphone twice as unidirectional as Cardioid . . .



Here is the difference in pickup patterns between the Cardioid and the Shure Super-Cardioid Microphone. Maximum sensitivity (100%) is achieved by sound approaching the Microphone, directly at the front. At 60° off the front axis sensitivity of the Super-Cardioid is only slightly less than the sensitivity of the Cardioid (69% against 75%). The Super-Cardioid insures, therefore, a wide range pickup at the front. Beyond the 60° angle, the sensitivity of the Super-Cardioid decreases rapidly. At 90°, the sensitivity of the Cardioid is 50%; the sensitivity of the Super-Cardioid 37½%; 12½% less. For sounds approaching at a wide angle at the back (110° to 250°) the sensitivity of the Cardioid is 33%; the Super-Cardioid 15½% or 17½% less. It has been proved mathematically that the ratio of front to rear pickup of random sound energy is; *Cardioid 7:1; Super-Cardioid 14:1.*

This additional directional quality is important in critical acoustic work. The Shure Super-Cardioid, employing the exclusive "uniphase" principle, gives such performance in a single, compact rugged unit.

SHURE BROTHERS

Designers and Manufacturers of Microphones and Acoustic Devices

225 W. Huron St., Chicago 10, Illinois • Cable Address: SHUREMICRO

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The frequency response is flat from 30 to 10,000 cps, with a maximum derivation of ±1.0 db. Two separate temperature-controlled oscillator units are standard equipment, either of which will maintain the carrier frequency to within ± 10 cps. Power output can be reduced from 250 watts to 100 watts by a switch on the control panel. All circuits are properly metered.

Radioactivity Meter

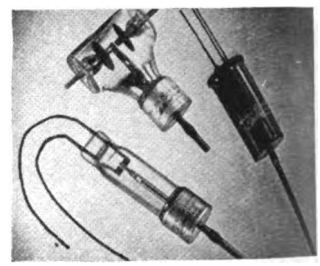
TYPE R-M-82 R METER is a sensitive electronic device for measuring, directly, very weak radiations from small quantities of radioactive materials. It will indicate values from 0.000001 to 20.0 R units. The meter is calibrated directly in fractions of R units on a linear scale of a 4-in. meter. It has five R ranges which are quickly selected by pushbuttons. Full scales on these ranges at maximum voltage are: 0.0001, 0.001, 0.01, 0.1 and 1.0 units. By using minimum voltage the least sensitive range can be extended to 20 R units for full scale. The meter proper is an electronic device which measures currents as low as 0.001 ma. A high-voltage power supply with adjustable output from 100 to 2000-v d-c is part of the apparatus. Safety switches are provided so that there is no possibility of the operator being exposed to the high voltages. High sensitivity of the unit does not affect its stability. Especially trained personnel is not required to operate the instrument. Various types of units are employed for holding the chemicals to be measured. The illustration shows one of several arrangements. In this case the material holder and electrodes are enclosed in a bell jar for evacuation. The unit operates from 115-v, a-c, 60 cps. It is housed in two steel cases, each measuring approximately 11 x 8 x 8 in.

Rowe Radio Research Laboratory Co., 2422 N. Pulaski Rd., Chicago 39, Ill.

Vacuum Switches, Capacitors

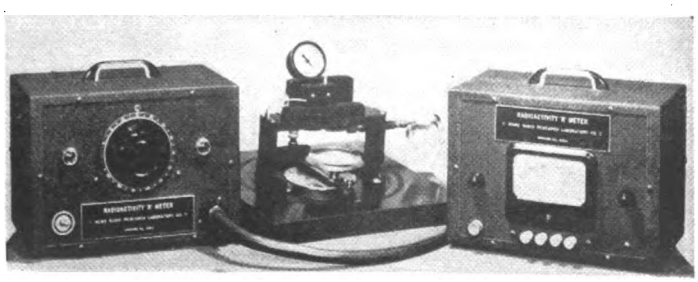
THREE GENERAL ELECTRIC (Electronics Dept., Schenectady, N. Y.) vacuum switches are available for such applications as limit switches, thermostatic controls, radio antenna switching, inertia-controlled devices, stratospheric applications or radio transmitter tank-coil assembly switching. Features of these switches include extreme flexibility (either slow operation or thousands of contacts per minute); low resistance contact; immunity to oil, water, and dust; non-inductive switch-control circuit; elimination of separate low-voltage control circuits; low contact pressure; small operating force; and long contact life. They are noiseless and vibrationless, mount in any position, require little space and no maintenance, reduce fire and explosion hazards, and easy to install and handle.

Type GL-1S21 is designed for high-frequency and high-altitude applications. It's circuit is a spdt type; maximum hold-off voltage across stationary contacts is rated approximately 7500 rms; maximum continuous current rms, 20 amp. The interrupting rating, resistive load for total life of 1000 operations at 7500 volts a-c rms is rated 15 amp a-c rms; 1,000,000 operations at 7500 volts a-c rms is 3 amp a-c rms total life of 500,000,000 operations at 7500 volts a-c rms is rated 0.1 amp a-c rms. The other type switches include types FA-6 and FA-15 which utilize spdt type circuits. Type FA-15 has a maximum voltage, a-c, of 3000 rms and a maximum continuous current, rms of 15



amp. Type FA-6 has a maximum voltage, a-c of 550 rms and a maximum continuous current, rms of 10 amp. Bulletin No. EXT-1 describes these units.

G-E vacuum capacitors have been designed for circuits where the peak voltages range from 7500 to 16,000 volts. They are for use as plate-tank and by-pass capacitors in diathermy equipment, and in other r-f oscillators or amplifiers. They can also be used as neutralizing capacitors in r-f amplifiers in conjunction with small, low-capacitance padding capacitors. Types GL-1L32, 1L21, 1L36, 1L38 and 1L33 are the 7500-v types with ratings of 6, 12, 25, 50 and 100 $\mu\mu$f capacitance respectively. Types GL-1L31, 1L25, 1L22, 1L23 and 1L24 are the 16,000-v types with ratings of 6, 12, 25, 50 and 100 $\mu\mu$f capacitance respectively. Bulletin No. ETX-2 describes them in more detail.



Federal Products

HIGH-VOLTAGE selenium rectifier stacks, heremetically sealed in glass, are available in several tube lengths and in various voltages up to 4000 volts from Federal Telephone &

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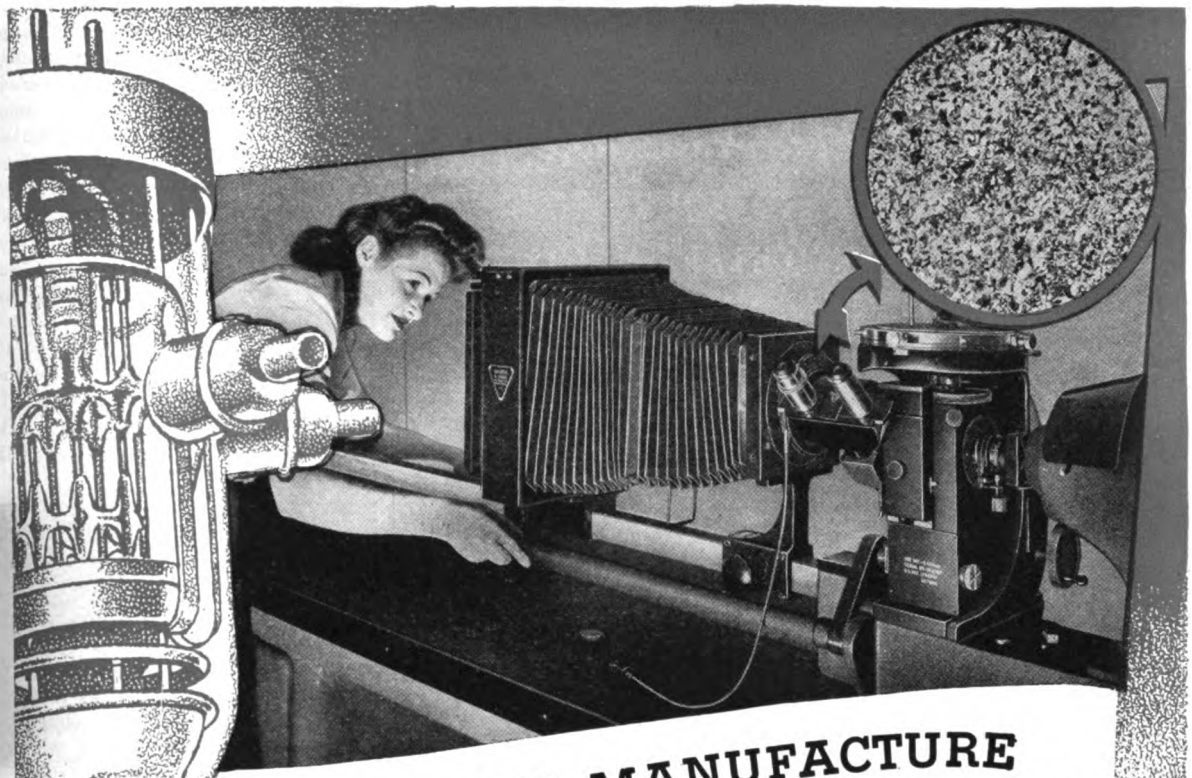

IN TUBE MANUFACTURE ALL SMALL DETAILS ARE LARGE TO *Federal*

From slender filament to anode block . . . *all* tube construction details, however small, are important to Federal. That is why this experienced and longtime manufacturer uses the illustrated high-magnification metallograph as part of its test equipment for checking raw material quality.

An example is the micro-photo inset. Here is shown oxide-free, high conductivity copper used for copper-to-glass seals . . . after the material has been reduced to a fine grain, non-porous structure through Federal's special metal-processing methods.

But whether copper, molybdenum or tungsten . . . they all are subjected to the same exclusive treatment and put through the same searching scrutiny . . . assurance that only the finest materials go to make up Federal tubes.

This exacting test is another good reason why Federal tubes are better tubes. Transmitting, rectifier, industrial power . . . they have a reputation that is deserved because they are *built to stay.*

Federal always *has* made better tubes.

FEDERAL TELEPHONE & RADIO FTR

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

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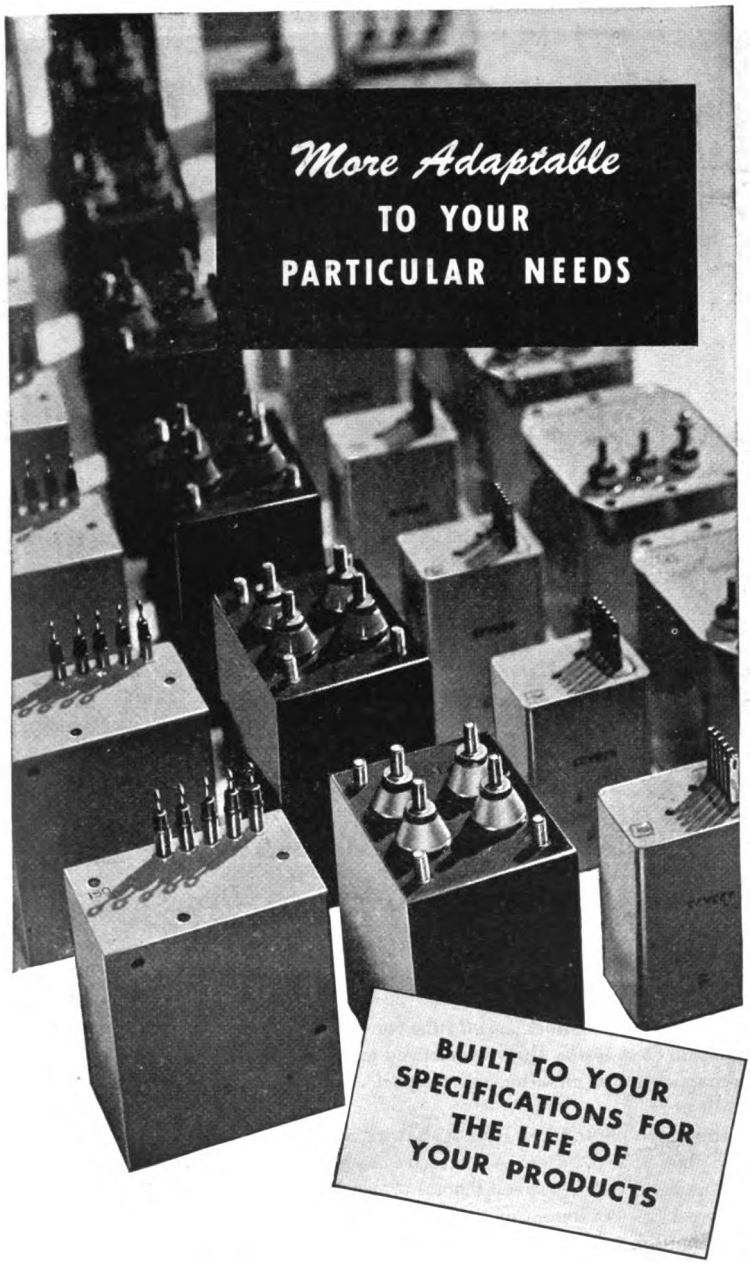


THE know-how gained in engineering transformers to war's exacting specifications is now available to solve your peacetime transformer needs. Stancor engineers are ready to study and master the toughest problems you can set them. Production men trained to exacting standards, with modern equipment and precision winding machinery, assure that highest specifications will be met in the finished product.

When you have a transformer problem, think first of Stancor. Competent sales engineers are ready to satisfy your most exacting transformer requirements.

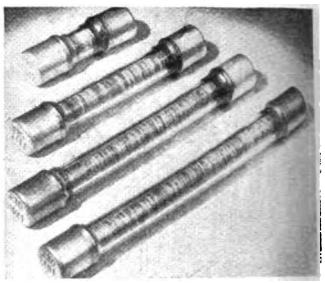
IN TRANSFORMERS STANCOR Gives More

STANCOR

STANDARD TRANSFORMER CORPORATION

1500 NORTH HALSTED STREET CHICAGO 22, ILLINOIS

Radio Corp., 67 Broad St., New York 4, N. Y. Stacks are easily and quickly installed. Electrical connection is made through heavy silver-plated ferrules at each end of the glass tube. The size of these ferrules permits mounting in 30-amp fuse clips unpolarized or polarized by addition of a simple member to the fuse clip assembly. Units are



light-weight, have long-life, and provide silent, trouble-free operation. The rectifiers can be used for application with cathrode-ray tubes in television, or as high-voltage, low-current rectifiers for a wide range of uses in other electronic devices.

Other Federal products include a comprehensive line of iron core magnetic components, custom-built to meet specific requirements and incorporating design innovations. Available with power ratings ranging from milliwatts to kilowatts, components can be provided in any

of the basic types of construction—open, frame, semi-enclosed, and hermetically sealed. Various terminal types can be supplied, including standard nut-fasteners and solder-type binding posts with porcelain bases. Hermetically sealed units utilize either compression bushings on porcelain bases, or glass-to-metal fusion seals in one piece covers. This type of seal withstands successive immersion in ice-water after hot tin dip. Applications of the components include plate and filament supplies, audio-frequency and modulation transformers, power transformers and reactors.

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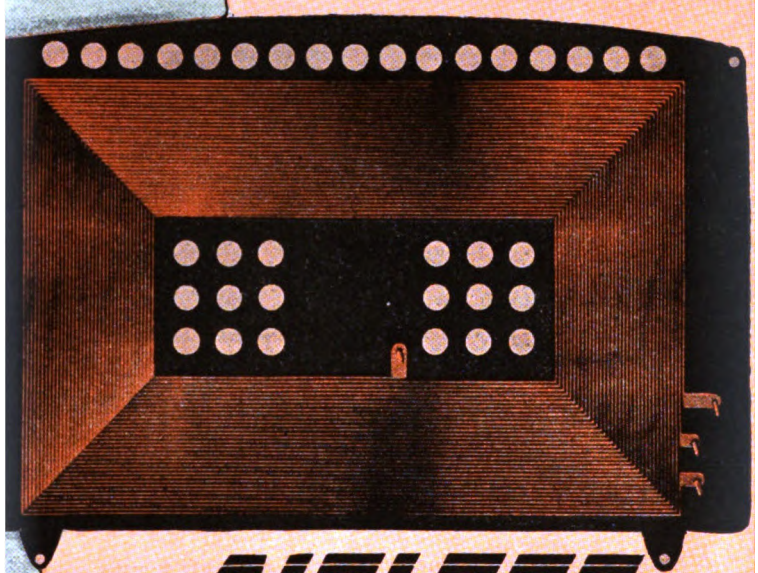

THE AIRLOOP

AIR DIELECTRIC THROUGHOUT ITS ENTIRE LENGTH

A radio engineers' dream come true . . . Flat sheets of copper die-stamped into perfect super-sensitive loops . . . The greatest development in loop antenna design and manufacture since 1920 . . . Being rectangular the Airloop has 27% more effective area . . . Better performance at lower cost . . . No set builder can afford to overlook the significance of the Airloop.

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Edgewise WOUND

INDUCTORS FOR R-F HEATING

A rugged, heavy duty inductor is a vital necessity for the construction of generators for R-F Heating. Experience has shown that B&W Edgewise Wound Inductors are admirably suited for this purpose. Requiring less space for a given amount of inductance, they also offer more heat dissipating surface than wire, for a given cross-sectional area.

B&W Edgewise Inductors can be furnished in coils from 1¼" inside to diameters in excess of 10 inches. The minimum size of strip is 3/16" x .050" while the maximum is 1" x .250". Inside or outside mountings are available either in plain or tapped coils. Rotary or continuously adjustable units are available with either inside or outside contact. Prompt delivery can be made on all types.

When designing your new electronic heating equipment, be sure and consider B&W Edgewise Inductors.

BARKER & WILLIAMSON

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Export: LINDETEVES, INC., 10 Rockefeller Plaza, New York, N. Y., U. S. A.

BRING COIL PROBLEMS TO COIL HEADQUARTERS!

Ultrahigh-Speed Relay

THE NEW STEVENS-ARNOLD Company (22 Elkins St., South Boston, Mass.) Millisec relay is a hermetically sealed sensitive relay capable of speeds up to 1,000 operations per second. The basic design of the moving elements makes the ultrahigh speed possible and assures reliability if operated in the usual

speed ranges. A glass envelope surrounds all moving parts and protects them from moisture, dust or corrosive fumes. Sensitivities down to ½ mw are possible. Ratings up to 5 amp can be obtained. Closing time can be less than 1 millisecond. Outside dimensions of relays rated at 115-v, a-c, 1-amp, are 3 in. high and 1½ in. base diameter.

Frequency Meters

VIBRATING REED frequency meters manufactured by Aero Instrument Co., 3907 San Fernando Road, Glendale 4, Calif., are direct reading frequency indicators for use on lines where the successful operation of a-c equipment depends upon maintenance of known or constant frequency. They are self-contained, requiring no auxiliary apparatus. They consist of a number of steel reeds, of high Q, each of which is tuned to a single frequency within the band covered by the instrument. Indication is by the visual pattern formed by the vibration of the reed in resonance with the line frequency. Excitation is electro-magnetic, and the reeds are the only moving elements. Frequency ranges are available from 10 cps to 500 cps in increments of half or full cycles. Meters of one cycle increment ranges can be read accurately to 0.5 cycle and meters of one-half cycle increment ranges can be read

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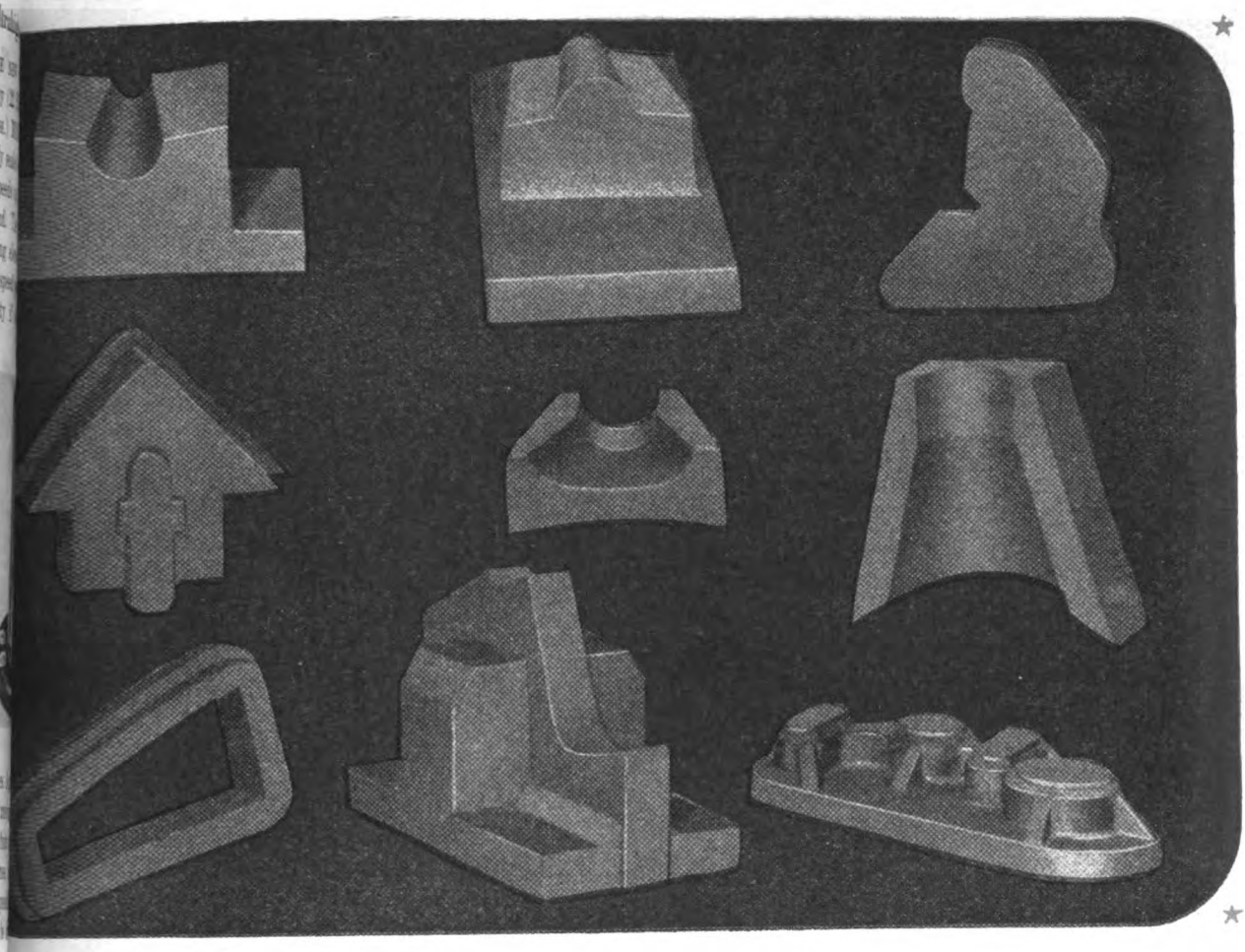

In this method OF TOOL AND DIE MAKING YOU BUY LESS STEEL AND REDUCE MACHINING COSTS

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It gives you details of FCC Air Hardening, Oil Hardening and other Cast-To-Shape Tool Steels and describes other FCC money-saving Tool Steel Specialties.

Get your copy—write for it today.

ADDRESS DEPT. E-36

FCC Cast-To-Shape, the modern method of tool and die making, is effecting important savings of time, trouble and money for an increasing number of manufacturers.

Even very intricate shapes can now be cast successfully within an eighth inch of finished size. This means that you buy less steel at the start and reduce machining costs substantially.

Tools which could not be made by conventional methods except in sections can often be fabricated from FCC Cast-To-Shape blanks in a single piece.

In many instances performance of the tool is better than can be obtained by fabrication from bar stock or forgings.

Particulars are available through Allegheny Ludlum representatives; or write for the booklet today.

ALLEGHENY LUDLUM
STEEL CORPORATION
Forging and Casting Division
DETROIT 20, MICHIGAN

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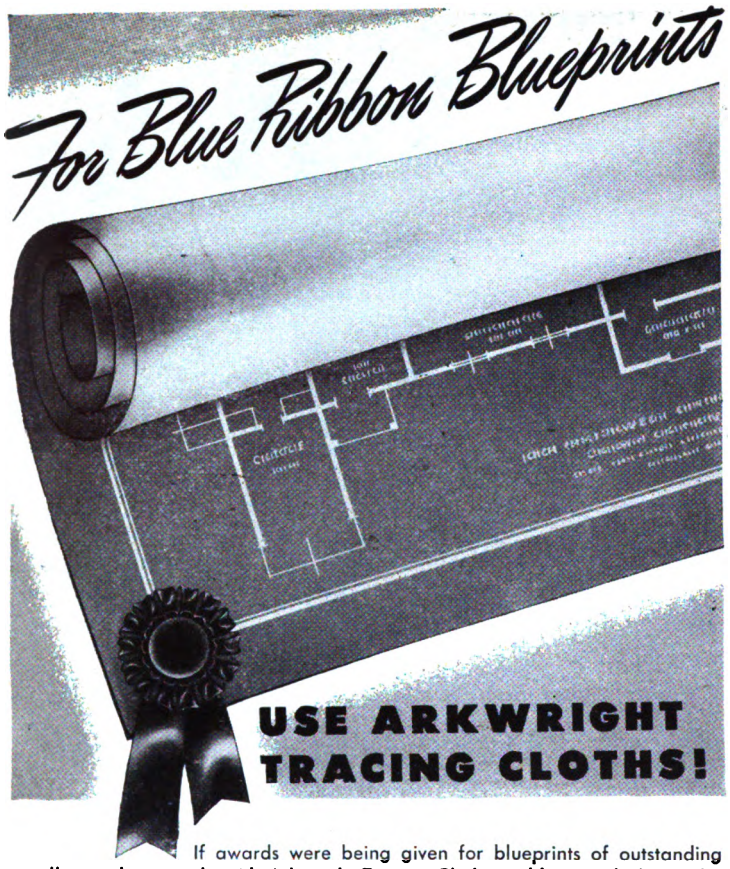

If awards were being given for blueprints of outstanding excellence, those made with Arkwright Tracing Cloth would certainly be in the Blue Ribbon class! Arkwright cloths contain no surface oils to become opaque and brittle with age. Exceptionally high, longer lasting transparency is obtained by Arkwright's exclusive mechanical processing methods.

EASES AND SPEEDS WORK. You'll find no pinholes, specks, dirt, stains or other imperfections to detract from its use as a drawing material or lower the quality of your reproductions.

TOUGH AND SERVICEABLE. Arkwright Tracing Cloths take erasure after erasure without smudging or wearing through. And re-inking is done without "feathering" or blotting. Countless copies can be made without tearing, fraying or curling of the original drawing.

FREE SAMPLES. Samples of this work-easing, job-improving cloth will be sent free on request to test on your own drawing board. Write: Arkwright Finishing Company, Providence, R. I.

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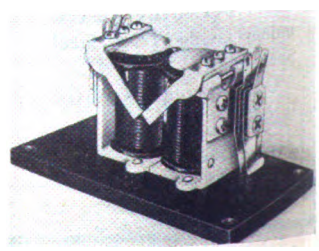
TRACING CLOTHS
AMERICA'S STANDARD FOR OVER 20 YEARS

to 0.1 cycle by comparing the relative amplitudes of the reeds. The following standard models are available out of stock and for early production in large quantities: Model 7004, range 59 to 63 cps; model 7007, range 57 to 63 cps; model 7005, range 48 to 52 cps; model 7006, range 58 to 62 cps; model 7009, range 47 to 54 cps; model 7002, range 48 to 52 and 58 to 62 cps; model 4009, range 380 to 420 cps.

Another instrument produced by Aero is Model No. 1001 running-time meter which is also direct reading for use on a-c lines. It is for use in applications where the successful operation of equipment depends upon the regular servicing of such equipment based on actual lapsed time. This meter automatically and cumulatively registers the total operating (or idle) time of any equivalent, machine, circuit or system to which it is connected. It has a range from 0 to 9999.9 hours and resets automatically at 10,000 hours.

Small Latching Relay

THESE NEW, SMALL latching relays are called "Latching Aerotrols" and are made by combining two of the manufacturer's standard line of Aerotrol 400 Series relays, with an interlocking armature. This design makes it possible to combine any two Aerotrols of similar or different types into a latching relay. They can be supplied in either single or double pile-ups and with all standard spring pile-up formations and combinations. Mounting arrangements are designed to specification. Units are available for either a-c or d-c operation with maximum voltage of 125-v d-c, or 120-v 60 cycle a-c. Dimensions are 1 $\frac{7}{8}$ x 2 $\frac{1}{8}$ x $\frac{11}{16}$ in. Magnetronic Div. of Cook Electric Co., 2700 Southport Ave., Chicago 14, Ill.



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Time Delay Thermal Overload Protection

Instantaneous Trip Overcurrent Protection

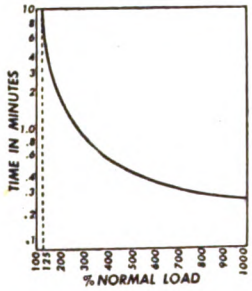
DT-1—THERMO-MAGNETIC RELAY

HERE IS HOW IT WORKS—

…e 10 times normal current the magnetic trip oper-. From 10 times down to 1.25 the circuit opens after …dicated time delay. ➡

…f you want to avoid expensive breakdowns of …pment due to unsafe overloads, you need the …l protection of the Roller-Smith type DT-1 …rmo-Magnetic Relay.

…get protection from dangerous overloads by …ans of a bimetal relay that opens the circuit before the winding temperature of the protected equipment becomes dangerous. There is a time delay before the relay opens which runs around 10 minutes at 125% rated load and 15 seconds at 1000% rated load. The magnetic trip operates instantly for currents in excess of 10 times rated load, the control circuit opens and the equipment comes off the line. For detailed information on the application and operation of the DT-1 overload relay, write for Catalog 6240 to Department E-6.



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Switchboard Instruments

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In Canada: Roller-Smith Marsland, Ltd., Kitchener, Ontario

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DIVISION OF ASSOCIATED SPRING CORPORATION

BRISTOL, CONNECTICUT

Radar Tube

GRAPHITE ANODES replace tantalum in these air-cooled radar transmitting tubes (type VT-127-A) to increase their life approximately thirty times over earlier types. The tube is called Marathon because specifications of the armed forces called for a minimum life of 500

hours in radar service and life tests in the field showed that the tubes were going strong at 5000 hours. Continuing field tests showed no signs of failure at the end of 10,000 hours. Sylvania Electric Products, Inc., Emporium, Pa.

Wire-Wound Resistors

ACCURATE FIXED wire-wound resistors, designated as type 188 Akra-Ohm, are small, close-tolerance units rated at 1 w with maximum resistance of 1 meg and having axial leads for convenient mounting by the leads on standard terminal strips. Units measure 1$\frac{1}{16}$ x $\frac{3}{8}$ in. The 3-in. axial leads of No. 20 tinned copper wire permit use of the resistor either in original equipment or as replacements in circuits where car-

bon resistors are not sufficiently accurate or stable. Standard tolerance is ± 1 percent, although higher accuracy up to ± 0.1 percent is available on special order. These units supplement the manufacturer's previous axial lead, type 181-A rated at 0.3 w and having a maximum resistance of 150,000 ohms. Shallcross Mfg. Co., Jackson & Pusey Ave., Collingdale, Pa.

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Radar Tube

GRAPHITE ANODES replac
in these air-cooled radar
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crease their life
thirty times over earlier
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Continuing field tests
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hours. Sylvania Electric
Inc., Emporium, Pa.

Wire-Wound Resistors

ACCURATE FIXED wire-wound
ors, designated as type
Ohm, are small, close-toleran
rated at 1 w with maximum
ance of 1 meg and having
for convenient mounting
leads on standard termin
Units measure 1⅝ x ¼ in.
axial leads of No. 20 tinned
wire permit use of the
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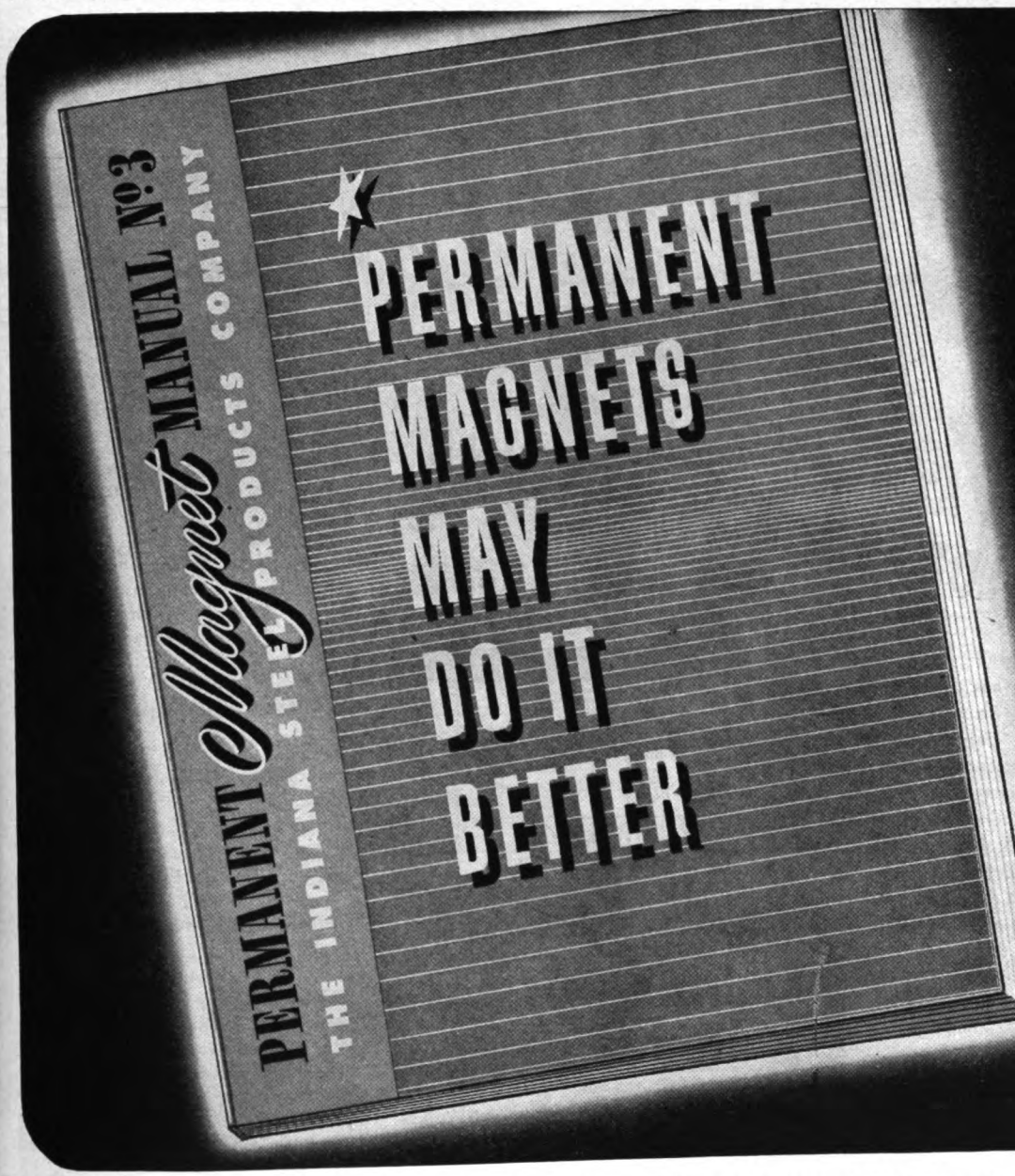
ohms. Shallcross Mfg. Co.,
& Pusey Ave., Collingdale,

PERMANENT MAGNETS MAY DO IT BETT



New Engineering Handbook on Permanent Magnets

If you are considering any application of permanent magnets to your product or manufacturing processes, you are welcome, without charge, to a copy of this new *Manual*.

This is a 32-page, illustrated reference work on magnets, prepared by the engineering and research staff of the world's largest producers. It contains data on the functions of permanent magnets; an outline of b types, with associated air-gaps; mate characteristics; and information on t engineering, designing and manufacture has many useful formulae, charts, graphs diagrams, of constant reference value.

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SPECIALISTS IN PERMANENT MAGNETS SINCE

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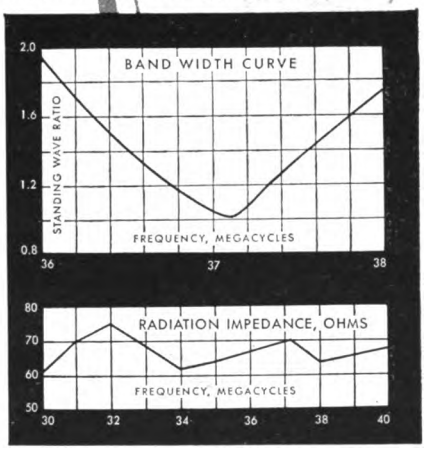
New FOLDED UNIPOLE ANTENNA

Another Example of ANDREW Ingenuity in Engineering

Concentrating on *electrical performance*, Andrew engineers have designed a unique Folded Unipole Antenna which—according to comparative tests—*easily outperforms other antennas at several times the price.*

Used for transmitting and receiving at frequencies from 30 to 40 MC and for powers up to 5,000 watts, this antenna has proved so successful that similar models for higher frequencies are now being designed.



FEATURES:

- Light weight — only 15 pounds — simplifies installation.
- Lightning hazard minimized by grounded vertical element.
- "Slide trombone" calibration permits exact adjustment for any frequency between 30 and 40 MC, using only a wrench. Optimum performance for that frequency is guaranteed without "cut and try" methods.
- Proper termination of coaxial transmission line. Unlike other "70-ohm" antennas, the Folded Unipole actually provides a non-reactive impedance with a resistive component varying between 62 and 75 ohms (see lower curve).
- Excellent band width, ideal for FM (see upper curve).

Andrew Co. specializes in the solution of antenna problems. For designing, engineering and building of antenna equipment, consult Andrew Co.

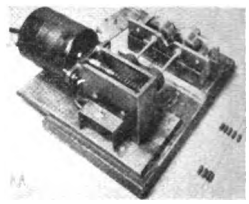
ANDREW CO.
363 EAST 75th ST., CHICAGO 19, ILL.

ANDREW

WRITE FOR FULL INFORMATION

Coil Varnishing Machine

ILLUSTRATED is a semi-automatic coil varnishing machine used to impregnate r-f coils with a uniform coating of varnish, to close tolerances, in a minimum amount of time. The unit is driven by a ⅓ hp synchronous motor. Weight of the varnish is controlled by adjustable



scrapers. An operator merely places a coil between two revolving drums and allows it several revolutions. A squeegee action created by the two revolving drums forces varnish between the coil turns. Coils are then ready for baking. Clippard Instrument Laboratory, Cincinnati, Ohio.

Spotting and Repeating Record Player

FAIRCHILD CAMERA & Instrument Corp., 88-06 Van Wyck Blvd., Jamaica 1, N. Y., announces its first postwar classroom teaching accessories, in the form of a simple, low-cost combination word-spotter record-player designated the Language Master, for schools, colleges, and other training centers. The unit is basically a record player with a device that permits accurately spotting and repeating any desired passages on a record for analysis. For

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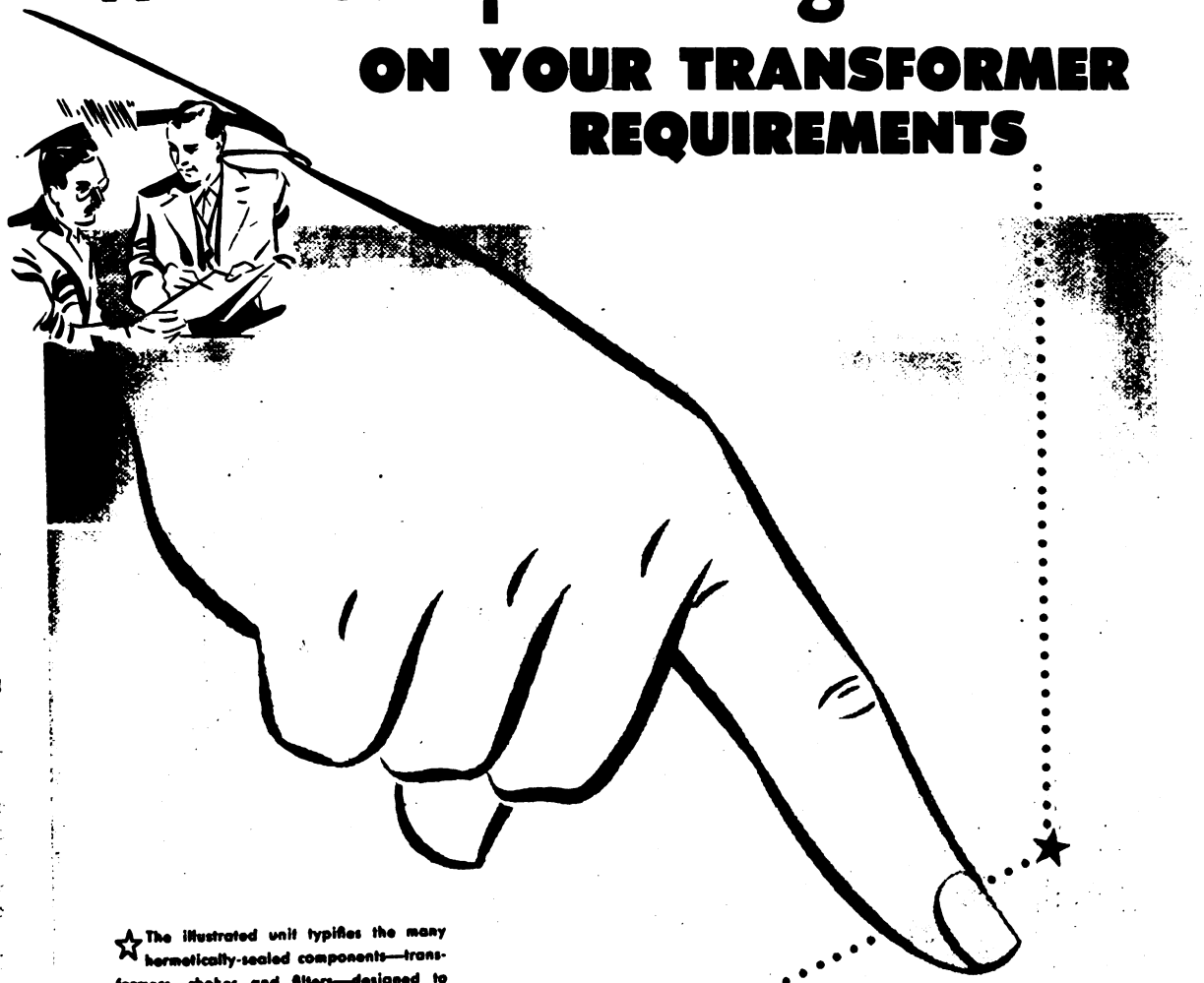
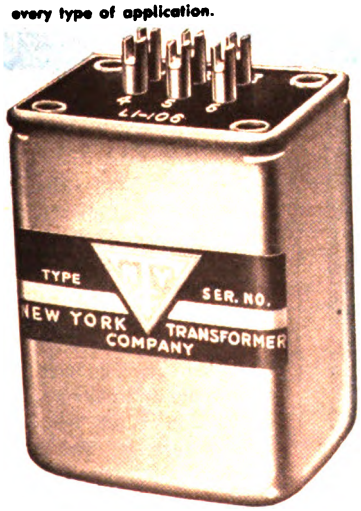


☆ The illustrated unit typifies the many hermetically-sealed components—transformers, chokes and filters—designed to meet unusual operating conditions for every type of application.



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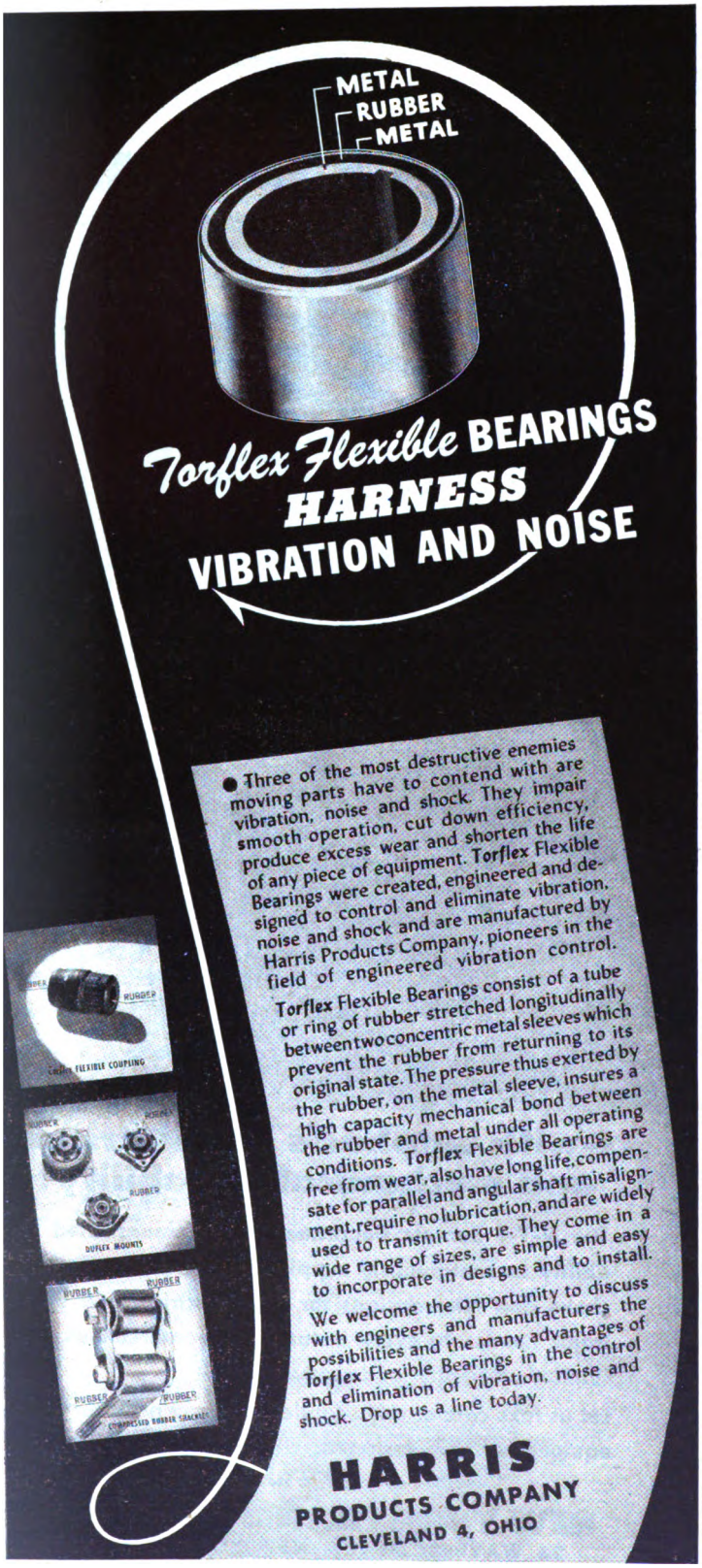

private study, the unit can be used with a pair of crystal headphones without an amplifier. A synchronous motor drives the turnable at 78 rpm. The recorder comes complete with the motor, a standard crystal pickup, spotting mechanism, 3-tube amplifier, and 5-in. permanent magnetic dynamic speaker. It weighs less than 20 lb and can be used on 110-v, 50/60 cycle ac.

Vacuum-Tube Voltmeter, Amplifier

MODEL NO. 451 VACUUM-TUBE voltmeter measures amplifier gain, network response, and output level at audio and radio frequencies. It is rated 25 mv, a-c, on the lowest range, 1000 v on the highest range, and 10 cps to 700 mc frequency range, with 7 $\mu\mu$f input capacitance. Other characteristics of

the unit include: single linear scale for all voltage and current scales; single zero adjustments for all a-c and d-c ranges; voltage regulated supply; stable operation; a rated accuracy of 2 percent of full scale values and large overvoltage capacity. The amplifier used with the voltmeter is model No. 101. Reiner Electronics Co., Inc., 132 West 25th St., New York 1, N. Y.

Tube Tester

MODEL NO. 2413 tube tester provides short and open element tests, plus a transconductance comparison check for matching tubes. Three-position lever switching provides simple and speedy operation and gives individual control for each tube element. The unit has a multicolor scale and comes supplied with instructions and test charts for quick reference. The case is furnished with a sturdy handle. It measures 10 x 10 x 5¾ in. Triplett Electrical Instrument Co., Bluffton, Ohio.

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private study, the unit ...
with a pair of crystal ...
without an amplifier. A ...
motor drives the turnta...
rpm. The recorder comes ...
with the motor, a stroboscope ...
pickup, spotting mechanism ...
amplifier, and 5-in. permanent ...
netic dynamic speaker. It ...
less than 20 lb and can be ...
110-v, 50/60 cycle ac.

Vacuum-Tube Voltmeter Amplifier

MODEL No. 451 VACUUM-TUBE ... meter measures amplifier ... work response, and output ... audio and radio frequencies ... rated 25 mv, a-c, on the ... range, 1000 v on the ... range, and 10 cps to 700 ... quency range, with 7 μμf ... pacitance. Other characteristics ...

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Tube Tester

MODEL No. 2413 tube tester ... vides short and open ... plus a transconductance ... check for matching tubes ... position lever switching ... simple and speedy ... gives individual control ... tube element. The unit has ... color scale and comes ... instructions and test ... quick reference. The case ... ished with a sturdy handle ... sures 10 x 10 x 6½ in. Triplett ... trical Instrument Co., ... Ohio.

The New Bendix-Pacific

VHF MOBILE RADIO COMMUNICATION SYSTEM

Bendix—famous for many recent new developments in radio for industry and home—now announces advanced VHF radio communication systems for mobile use.

The new systems, which offer greatly improved performance characteristics and economy of operation, are available for use in three of the Very High Frequency bands—30-44 megacycles, 72-76 megacycles and 152-162 megacycles.

All the equipment has been designed to use low input power. Any extended service can be provided with relay facilities.

For five years Pacific Division's radio research group has been working with military experts on advanced designs of VHF communication and control systems, and the equipment embodies the latest developments commercial application. In addition to new perfo ance characteristics, the Bendix-Pacific equipm has been designed for compactness, long life for easier service and maintenance.

Whatever application of radio voice communica you are planning, Pacific Division is intereste explaining the advantages of the new equipme you. Pacific Division, Bendix Aviation Corpora 11677 Sherman Way, North Hollywood, Califo

Sales Engineering offices in New ... and St. Louis.

One of the new VHF communication units combining transmitter and receiver in a single cabinet for either mobile or fixed station installation.

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PLUGS and JACKS

for every known application!

Built in accordance with latest Signal Corps and Navy specifications, Amalgamated Plugs and Jacks are tropicalized to make them fungus resistant, waterproof and moistureproof when called for. Insulators of these components are designed to withstand extremes of temperatures for −67°F to +167°F, at humidities up to 100%. We also specialize in producing Plugs which will bear up under the high heat met in rubber molding cord sets.

NOTE: Amalgamated Engineers will gladly consult with you on the design and development of Plugs and Jacks for special applications—present or postwar.

PLUG PL-55 and N.A.F. 1136-1

Long sleeve, two-conductor plug, mate to Jack JK-34-A. Withstands minimum of 60 cycles AC. potential of 500 volts effective, applied between any two terminals for not less than two seconds. Meets minimum insulation value of 2000 megohms between conductors at 68°F at humidities up to 100%.

PLUG, STYLE "A"

Two-conductor, special type plug for use with Neoprene or Buna S molded cords. Same specifications as PL-55.

PLUG, STYLE "D"

Two-Conductor, special type plug for use with Neoprene or Buna S molded cords. Same specifications as PL-55.

PLUG PL-204

Hand set. A special plug wherein both a modified plug, PL-55 and PL-68, are held in place by a phenolic case. Same specifications as PL-55 and PL-68.

JACK JK-26, N.A.F. 215284-2

Two-conductor Jack, mate to PL-54. Tropicalized. Withstands 60 cycle AC potential of 500 volts effective, applied between any two terminals for not less than two seconds. Meets minimum insulation value of 2000 megohms between conductors at 68°F, at humidities up to 100%.

JACK JK-48

Light duty, two-conductor Jack, mate to Plug PL-291 and Plug 291-A.

PLUG PL-54, PL-540, PL-354, N.A.F. 215285-2

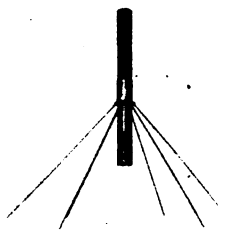
Short sleeve, two-conductor plug, mate to Jack JK-26. Same specifications as PL-55.

AMALGAMATED RADIO TELEVISION CORP.

476 BROADWAY • NEW YORK 13, N. Y.

VHF Broad Band Antenna

TYPE MS-105A broad-band dipole antenna operates in the range of 108 to 132 mc in aeronautical service. Anywhere in this range, and without adjustment, the antenna will match into a 52-ohm coaxial transmission line and produce no more than a 1.5 to 1 standing wave ratio. A frequency range of 100 to 156 mc can be used with a standing wave ratio of not more than 2 to 1. The field pattern of the antenna is non-directional in the horizontal



plane, and in the vertical plane is essentially the same as that of a standard dipole antenna, except that it has better frequency coverage. Polyethylene is used instead of air as a dielectric. Completely assembled, the antenna has an overall height of 38½ in. It weighs 4 lb. 10 oz. Mounting may be either on a wood or metal mast. The connector socket located inside the tublar base will fit a standard AN-PL-259A connector plug. A standard 52-ohm type AN-8/U coaxial cable or any cable similar to this may be used with the antenna. Bendix Radio, Baltimore 4, Md.

Copper Oxide Rectifier

A NEW, FULL-WAVE copper-oxide rectifier, rated at either 12-v a-c or 50 ma d-c has been added to the line of Coprox rectifiers available from Bradley Laboratories, Inc., 82 Meadow St., New Haven 10, Conn. The new unit is actually a double unit of the manufacturer's model CX-4D4-F23, recently redesigned to handle greater capacity than the original version. The single unit is now rated at 6 v, a-c and 50 ma, d-c continuous. It mounts on a single screw, is fully enclosed and completely sealed with a special plastic compound. Pre-soldered lead wires prevent overheating during assembly.

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WHETHER he's Mr. Big of Industry or plain Mr. Homebody, the performance of your product's electrical insulation can make or break *his* good will, influence *your* future sales. Look at *all* the hazards of faulty or insufficient insulation. See why hundreds of manufacturers are protecting *their* products with BH Fiberglas Sleeving—the insulation that's way ahead in every important requirement, thanks to the exclusive BH process.

BH Fiberglas Sleeving is *permanently* flexible and non-fraying, the *original* sleeving to combine these qualities with heat resistance to 1200°F., with high tensile strength, and with resistance to moisture, oil, grease and most chemicals. It's easier to handle and install, and lasts longer in severest service. That's why BH Special Treated Fiberglas Sleeving, for instance, does a trouble-free job when the heat's on—why Mr. Room Heater Customer is sold *for good* when the heater's BH-equipped.

Whatever your product may be, if it depends on electrical insulation, you can count on one of the three BH Fiberglas Sleevings to meet your strictest needs. Send for free BH samples *today* —test them yourself—expect surprising results!

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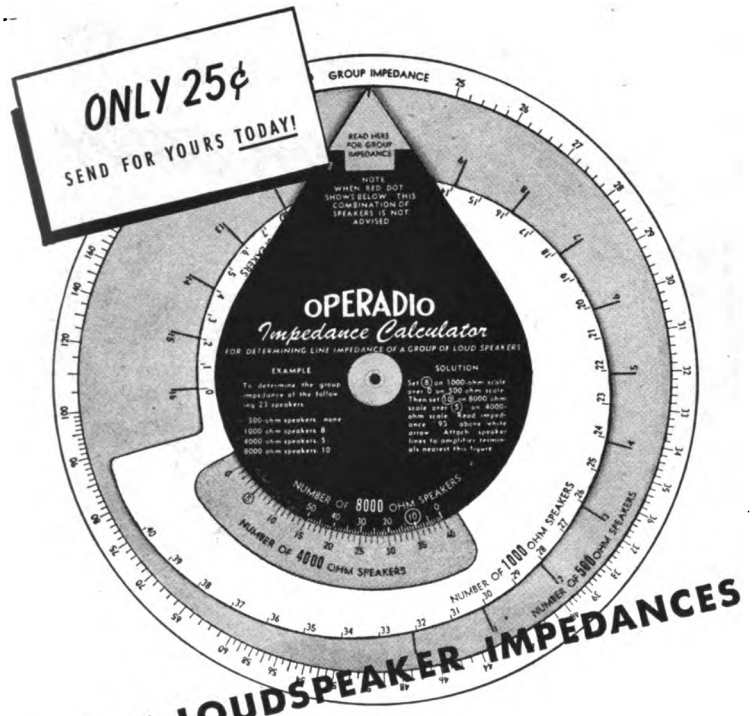

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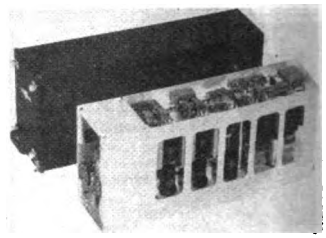
Aircraft Communication Receiver

A NEW CRYSTAL-CONTROLLED, lightweight aircraft communication receiver (type 51K-1) from Collins Radio Co., Cedar Rapids, Iowa, uses the Collins Autotune for selecting the channel of operation. The receiver has ten different easily preselected frequencies for reception



anywhere within the range of 2.4 to 18 mc. Two seconds is the maximum time required for the Autotune to change channels. The receiver is designed for commercial transport planes. It fits into ½ ATR unit, and weighs less than 20 lb. It operates from a 24-v d-c source. A 12-v model is also available.

D-C to A-C Converter

A D-C TO A-C ROTARY converter suitable for special applications where close control of frequency is desired is announced by Carter Motor Co., 1608 Milwaukee Ave., Chicago, Ill. Output frequency, indicated on a built-in, vibrating reed type fre-

quency meter, can be manually corrected to 60 cycles by a power rheostat connected in series with the field coil. Types of converters available include models for input voltages from 6 through 64 volts for battery conversion, and from 110 to 120 volts for line conversion with ratings from 40- to 250-w continuous duty.

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Represents a form of electricity that is hard to hold or control.

Controlling electrical currents is Formica's big job and it can do it today better than ever before. Some new developments in material and processing have provided grades that reduce high frequency losses to a new minimum, stand more arching, resist more heat.

Glass Cloth and glass mat with melamine resin have stepped up insulating efficiency, increased mechanical strength, produced a laminated material on an entirely new level of quality for many purposes.

These new materials retain the machinability and workability that always adapted laminated material to mass production. They mean better insulated electrical devices at low production costs.

The Formica Insulation Company • 4661 Spring Grove Avenue • Cincinnati 32, Ohio

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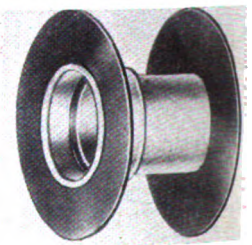
Power Supply

MODEL H (Porta-Power) provides hum-free operation of 4, 5, or 6 tube (1½ v) battery farm or portable radios, from 105-125 v, 50-60 cycle lines. The hum is eliminated by a two section filter composed of three capacitors of very high capacitance and two oversized iron-core chokes in the A supply; and two high capacitance capacitors and an oversized choke in the B supply. The A supply is rated 1.5 v at 200 ma; 1.35 v at 250 ma; 1.55 v at 300 ma; and 1.35 v at 350 ma. The B supply is rated 90 v at 13 ma and 101 v at 8.5 ma. The circuit is designed for optimum voltage regulation and changes in line voltages. The unit weighs 4½ lb. General Transformer Corp., 1250 W. Van Buren St., Chicago 7, Ill.

One-Piece Coil Forms

NEW DIE-FORMED bobbin coil forms for speaker field coils come in complete, strong one-piece assemblies, ready to go on mandrels of coil winding machines. The entire coil



base is shaped by die in one piece from spirally wound, heat-treated dielectric materials. Precision Paper Tube Company (2023 W. Charleston St., Chicago 47, Ill.) makes these coil forms to shape, measurement and other specifications.

Phonograph Turntable

IMMEDIATELY AVAILABLE are phonograph turnable units produced by Eastern Electronics Corp., 41 Chestnut St., New Haven, Conn. Correct and uniform speed is secured through the use of a motor of ample capacity, preloaded to operate on the flattest portion of the torque-speed characteristic. Full-floating rubber mountings and rubber-cush-

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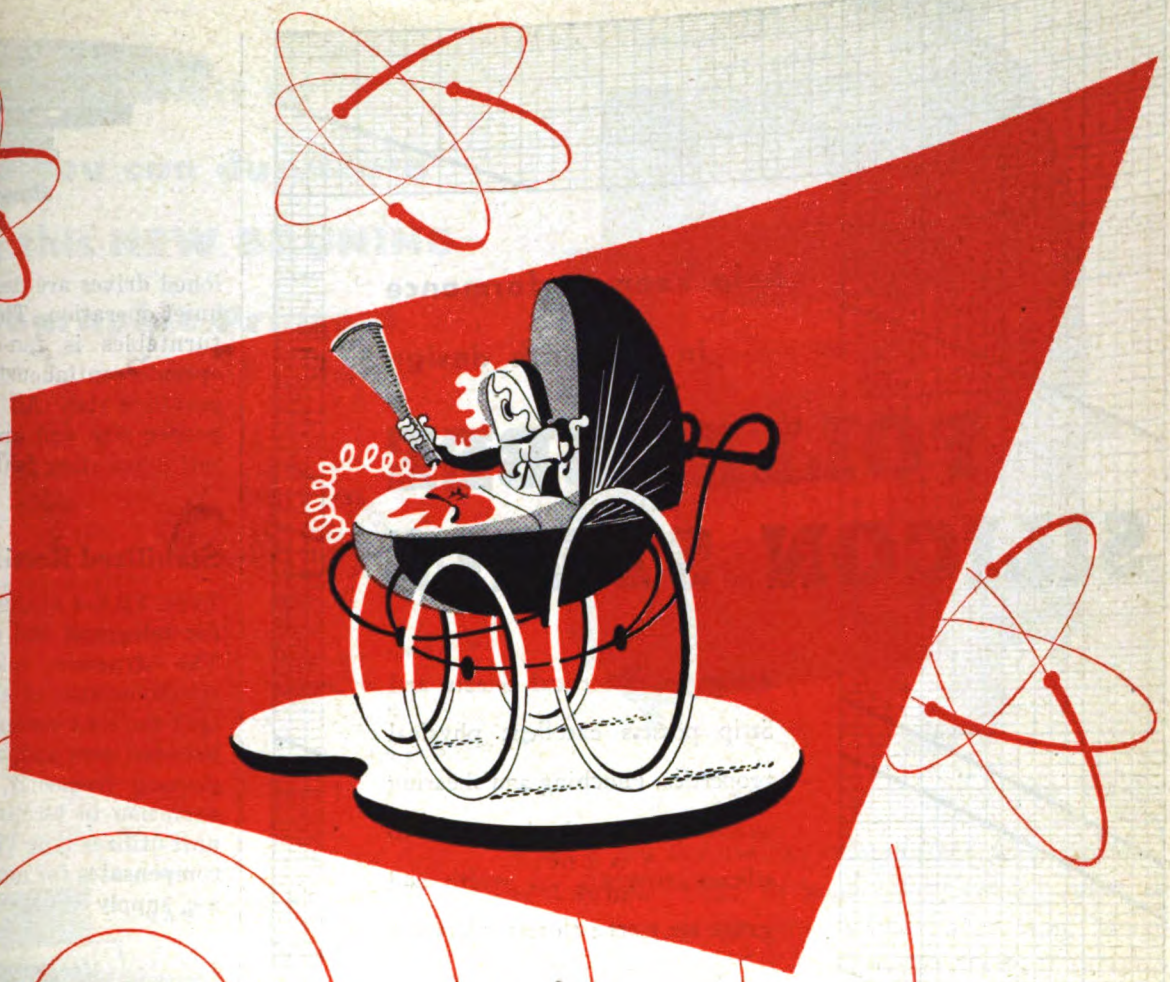

We grew up with electronics

Our engineers and executives grew up with Electronics. Before the war we manufactured commercial radio equipment. During the war we greatly expanded our engineering and research staff and did extensive work in advanced electronics for the Army and Navy. Our present engineering and research facilities occupy more than 30,000 square feet of space. Our current production program is centered on communications equipment for rail, air, highway, marine and commercial use. Other products, notably in the field of industrial electronics, are under development.

Aireon's engineering and research staff will be glad to consult with you on your electronic problems. Your inquiry will have prompt attention.

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help keep performance
in line with design

FOLLANSBEE SILICON STEELS

Follansbee Electrical Sheets and Strip possess excellent physical properties. Punching and shearing quality is in the highest ratio to silicon content . . . width and gauge are to the closest tolerances . . . surface finishes and space factors meet exacting specifications.

And—equally important—Follansbee silicon steels are made to provide the precise magnetic characteristics required. That's why it will pay you to check with Follansbee for Electrical Sheets or Strip—silicons that help keep the performance of your products in line with their design.

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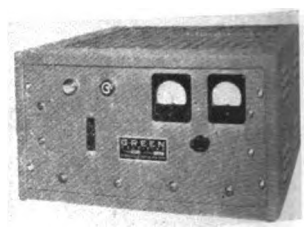
POLISHED BLUE SHEETS • SEAMLESS TERNE ROLL ROOFING

ioned drives are designed to assure quiet operation. The motor of these turntables is fan-cooled and will operate continuously with low temperature rise. All bearings are of proper size and are provided with self-lubricating features.

Stabilized Rectifier

TYPE TRX-4 STABILIZED rectifier is for telegraph and similar services. The dynamic voltage regulation characteristic of the unit is such that the load current may be varied between zero and maximum at any demand frequency, with negligible variation in terminal voltage. The unit utilizes type TRX circuit which compensates for normal variation in a-c supply voltage to the rectifier



unit. Other features of the unit include: completely non-resonant filter; optional connection to 115- or 230-v, 50/60 cycle a-c supply; optional output ranges of either 110/120 or 150/160 v; circuit breaker switch protection on a-c side; volmeter, ammeter, and supervising lamps; and facilities for mounting in standard 19-in. panel cabinets. Models are available for 1-, 2-, 4- and 7-amp capacity. Green Electric Co., Inc., 130 Cedar St., New York, N. Y.

Vibration Pickup

DEVELOPED TO MEET the requirements of aircraft engine testing, this pickup has exceptional durability under conditions of extreme vibration, high output signal level, freedom from frictional effects, limiting response at low amplitudes,

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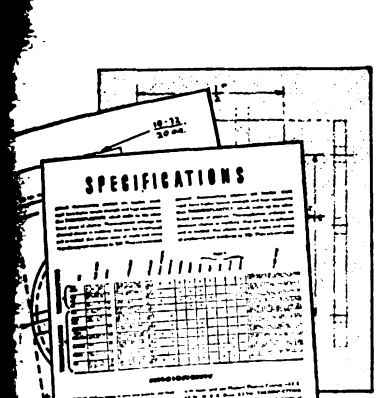
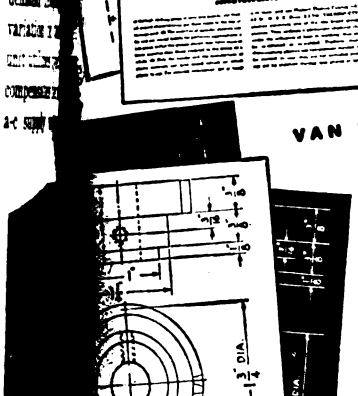


TRACINGS

LINE DRAWINGS

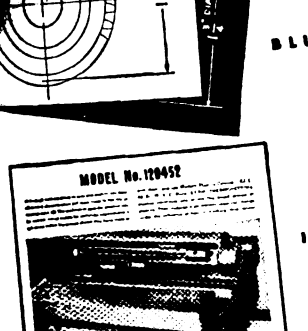
SPECIFICATIONS

VAN DYKE NEGATIVES



BLACK AND WHITE PRINTS

BLUE PRINTS



ILLUSTRATIONS

• Now you can use this new *photographic* reproduction process right in your own drafting room or engineering department! With the Bruning Model 2 BW and Copyflex Continuous Printer, there is practically no limit to the kind of materials you can duplicate! You can have copies of anything typed, printed, illustrated or drawn. Original material with copy on both sides can be reproduced from one or both sides.

Both Copyflex photographic and BW Black and White sensitized materials are exposed on the Model 2 Printer. Copyflex prints are developed with three trays and a simple drier (readily available). BW prints are developed in the Model 153M developing machine, combined in a convenient stand with the printing unit. Moderately priced, the Model 2 Printer and 153M Developer increase your duplicating scope—provide a wider range of duplicating advantages. Mail the coupon for literature about this modern print-making method.

RLES BRUNING COMPANY, INC.

Since 1897

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CHARLES BRUNING COMPANY, INC.
4712-24 Montrose Avenue, Chicago 41, Illinois
Please send me complete information on your Model 2 BW and Copyflex Continuous Printer—and on other Bruning printing and developing machines for making Bruning Black and White Prints.

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Company.....

Street.....

City.....*State*.....

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A roster of all Eicor products, in their various types and sizes, shows an astonishing number and diversity. But of special interest to users of rotary electrical equipment is our ability to produce units unusual in design or performance . . . and do it quickly, accurately, and at reasonable cost.

Serving in an endless list of special applications, these developments include . . . the smallest commercially produced dynamotor, for 10 watts continuous output, in a 2-5/16" diameter frame and weighing only 34 ounces . . . a motor rated 1/5 hp at 3800 rpm for intermittent duty, 2-5/16" in diameter, weight 38 ounces . . . an aircraft inverter to supply output of 100 va, 400 cycle, single or three phase, in a 3" frame and unit weight of 5¾ lbs. . . . a .6 hp, 4000 rpm, intermittent duty motor, 4" in diameter and 9½ lbs. weight . . . a dynamotor 4-1/16" in diameter which supplies 32 watts continuous output per pound weight . . . a 12 vdc motor rated ¼ hp at 1700 rpm with 150 in. lbs. lock torque in a 5¼" frame.

These highlights are an indication of what EICOR has done in the past. In the days to come our creative engineering will solve similarly difficult problems involving motors, dynamotors, and generating equipment for industry. Your inquiry is invited.

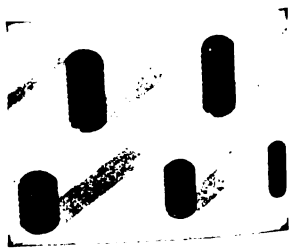
EICOR

EICOR, INC. 1501 W. Congress St., Chicago, U.S.A.
DYNAMOTORS • D. C. MOTORS • POWER PLANTS • CONVERTERS
Export: Ad Auriema, 89 Broad St., New York, U. S. A. Cable: Auriema, New York

and stability of calibration over wide temperature ranges. Output is proportional to vibratory velocity, with uniform response from below 10 cps to approximately 1000 cps, and usable response to 4 cps. The pickup is usually operated as a seismic instrument, but can be furnished with facilities for direct attachment of a light moving coil to the structure whose vibration might be influenced by a heavier mass. Pickups are supplied with a special flexible pigtail lead, and are easily and quickly converted for use in either horizontal or vertical planes without affecting calibration. The MB Manufacturing Co., Inc., New Haven, Conn.

Screw-Type Iron Cores

BECAUSE THESE IRON cores utilize threaded cores they are designated as Screwtype molded iron cores. No brass core screw is necessary for their adjustment. There is no metal in the field of the coil and the cores themselves are not grounded. As a result a higher *Q* is obtained. Stackpole Carbon Co., St. Marys Pa.



A transmitter-receiver made by Bendix is completely interchangeable with British equipment.

More than 7,900 watts of power are used by the 435 vacuum tubes in the radio equipment of a B-29.

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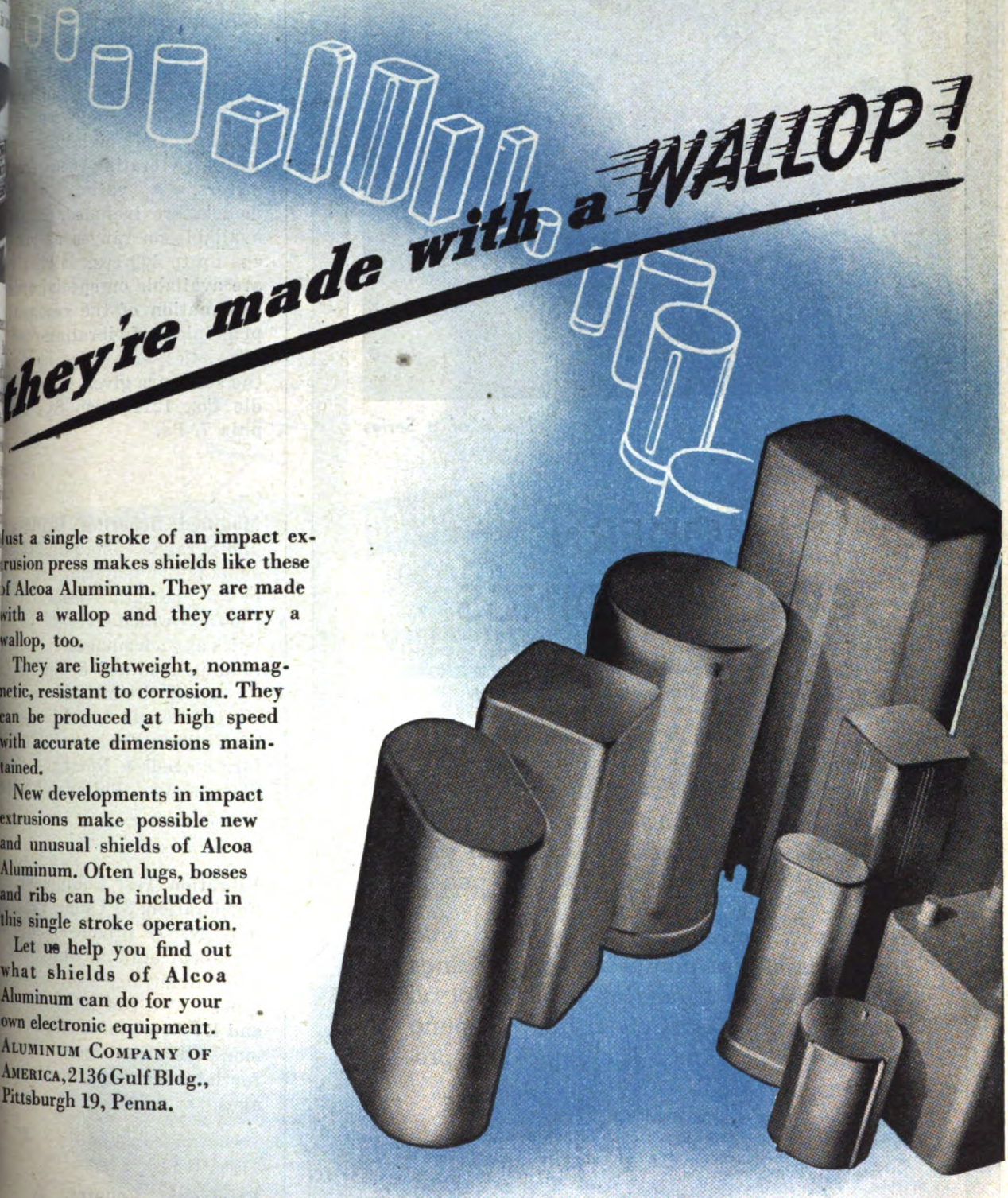
they're made with a WALLOP!



Just a single stroke of an impact extrusion press makes shields like these of Alcoa Aluminum. They are made with a wallop and they carry a wallop, too.

They are lightweight, nonmagnetic, resistant to corrosion. They can be produced at high speed with accurate dimensions maintained.

New developments in impact extrusions make possible new and unusual shields of Alcoa Aluminum. Often lugs, bosses and ribs can be included in this single stroke operation.

Let us help you find out what shields of Alcoa Aluminum can do for your own electronic equipment. ALUMINUM COMPANY OF AMERICA, 2136 Gulf Bldg., Pittsburgh 19, Penna.

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No. 6 of a Series

MODERN COIL WINDINGS

Partial View of Automatic Coil Winding Department

Coto-Coil Electrical Coil Windings have pioneered in the industry since its infancy. Coto-Coil engineering skill and products have met all demands of two world conflicts and the intervening years of peace.

Now, in a modern plant, equipped with every facility for producing coil windings which may be depended on to meet all requirements, Coto-Coil is busy meeting the increasing demands of peacetime production.

Our 28 years of experience in coil design and production are at your service.

COTO-COIL CO., INC.

COIL SPECIALISTS SINCE 1917

65 PAVILION AVE. PROVIDENCE 5, R. I.

Literature

Frequency Meters. Bulletin No. 1770 supersedes this manufacturer's bulletin No. 1695. The newer edition contains sixteen pages and is illustrated with photographs and diagrams of switchboard, portable and miniature types of Frahm vibrating-reed frequency meters. A variety of special models are included. Meters are available on ranges as low as 15 cps up to 400 cps. Higher ranges are available on special order. An explanation of the resonant reed principle and vibrating-reed characteristics as well as how to read the scale are given. James G. Biddle Co., 1211 Arch St., Philadelphia 7, Pa.

Modified Schering Bridge. New photographs, photo-diagrams and explanatory material are included in a recently issued catalog, E-54 (2) which gives the characteristics and advantages of this direct-reading modified Schering bridge for use in the measurement of dielectric constant and power factor of a dielectric in solid or liquid form. Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Vibration Test Equipment. L.A.B. Corporation, 31 Union Place, Summit, N. J. produced an 8-page loose-leaf bulletin which describes and illustrates three different types (VU-DM-100, VU-DM-500 and RV-3) of three and two-dimension vibration tests equipments for laboratory and production usages.

Electronic Counter. A 16-page bulletin illustrates and thoroughly describes Model No. 67, two-decade electronic counter for high-speed counting. This instrument is one of the adaptations of the Potter standard electronic counter-decade. Potter Instrument Co., 136-56 Roosevelt Ave., Flushing, N. Y.

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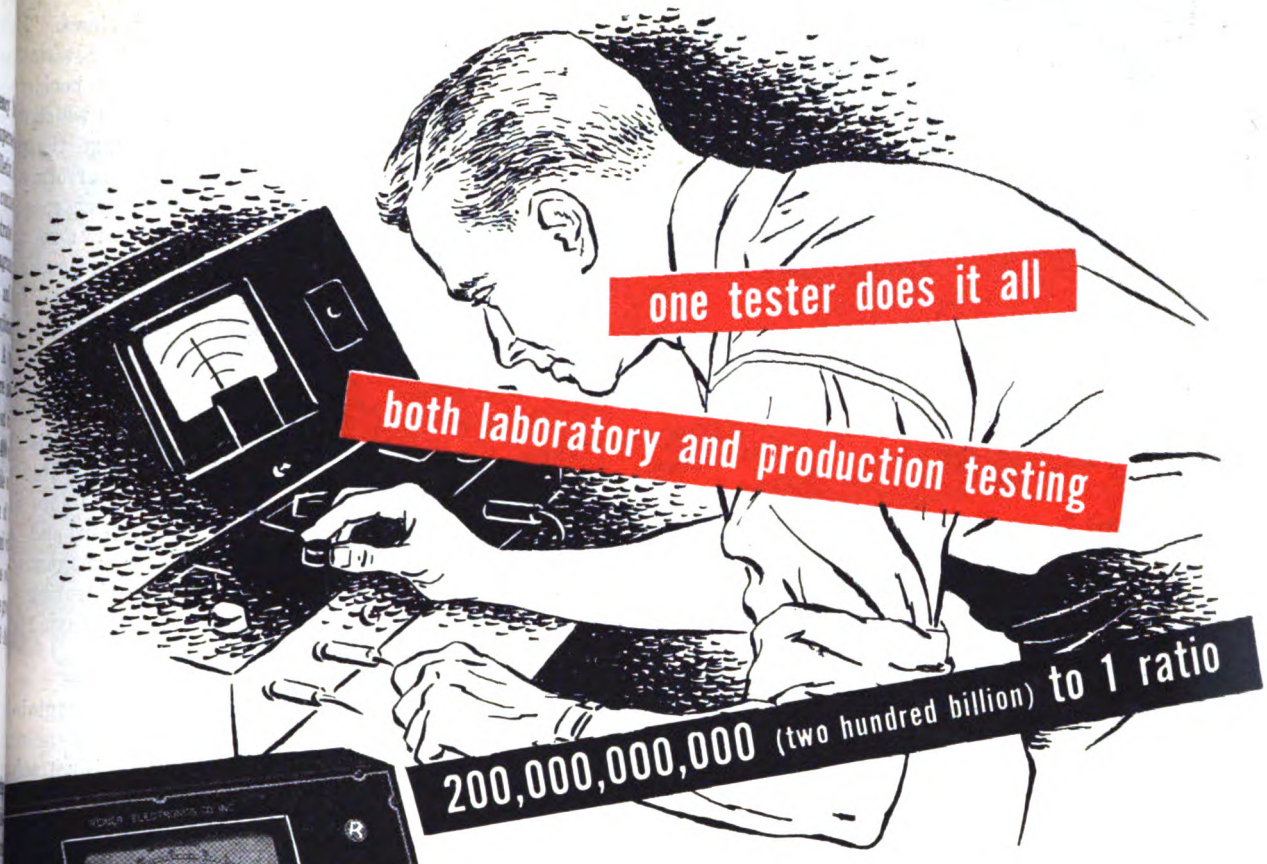
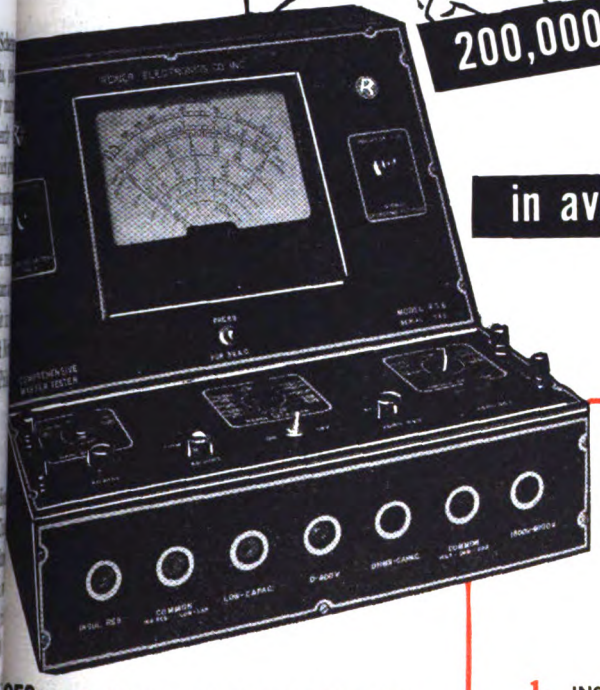


in available resistance measurements

REINER MODEL 456
COMPREHENSIVE MASTER TESTER



The highly accurate and efficient Reiner Master Tester combines in one compact unit an unusually large number of measurements and ranges — equivalent to 61 individual single range meters. It is an electrical measurements laboratory, especially designed for industry, with *eight* types of testers in one instrument:

1. INSULATION TESTER
2. CAPACITY METER
3. OHM METER
4. A. C. VOLTMETER
5. D. C. VOLTMETER
6. A. C. AMPERE METER
7. D. C. AMPERE METER
8. IMPEDANCE-INDUCTION METER (with charts)

GES A. C. Current 6-15-30-60-150-300-600-3000-6000-15000-30000 M. A. ★ D. C. Current 30-60-150-300-600-1500-3000-6000-15000-30000 ★ A. C. Volts 3-6-15-30-60-150-300-600-1500-6000 ★ D. C. Volts 6-15-30-60-150-300-600-3000-6000 ★ Ohms 0-1000-10000-100000-1 meg-neg-100 meg-1000 meg ★ Insulation Tests 500 0-10000 megohms; 1000 volt/0-20000 megohms apacity High 5-2000 .5-200 .05-20 .005-2 .0005-.2 05-.02 microfarads ★ Capacity Low 1-100 micro- ds ★ Frequency range without probe A. C. 10 cps - 100 K. C., 25 microfarads input ca- ty. With probe provided 10 K. C. - 500 M. C., 1 rofarad input capacity.

Insulation testing at 500 volts to 10,000 megohms; at 1,000 volts to 20,000 megohms. ★ Capacity measuring one micro-microfarad to 1,000 microfarads. ★ Resistance measurements 0.1 to 1,000 megohms.

SIMPLE OPERATION: wide scales on the 9" rectangular meter permit direct, easy reading.

e: 16" x 12½" x 15" **WEIGHT:** 33½ lbs.
vered complete ready to use, with set of high voltage
t, set of shielded test loads, high frequency probe.

Further information on this and other Reiner precision equipment ite to REINER ELECTRONICS Co., 125 W. 25 St., New York 1, N. Y.

Reiner
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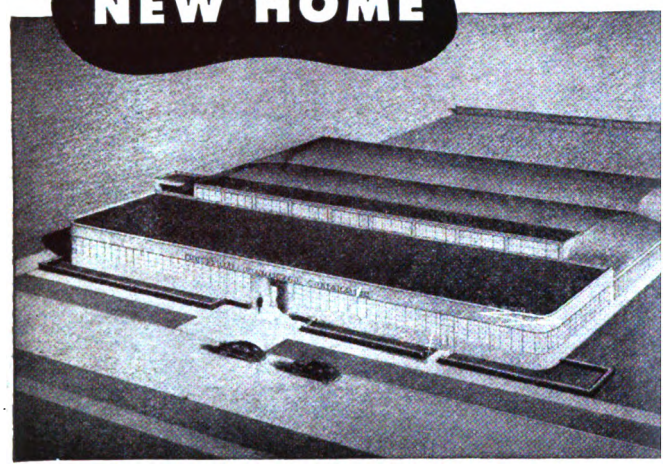
NEW HOME



THE WORLD'S MOST
MODERN CONDENSER PLANT
with these outstanding features

★ 1,000,000 VOLT RESEARCH LABORATORY
★ VERY LATEST PRODUCTION EQUIPMENT
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From this NEW ultra-modern factory come capacitors carefully engineered and accurately produced. Staffed by skilled engineers and backed by 16 years of technical progress, Industrial Condenser Corp. is supplying capacitors for every application. If your specifications call for Electrolytic, Paper, Oil, or Motor capacitors, look to Industrial Condenser Corporation.

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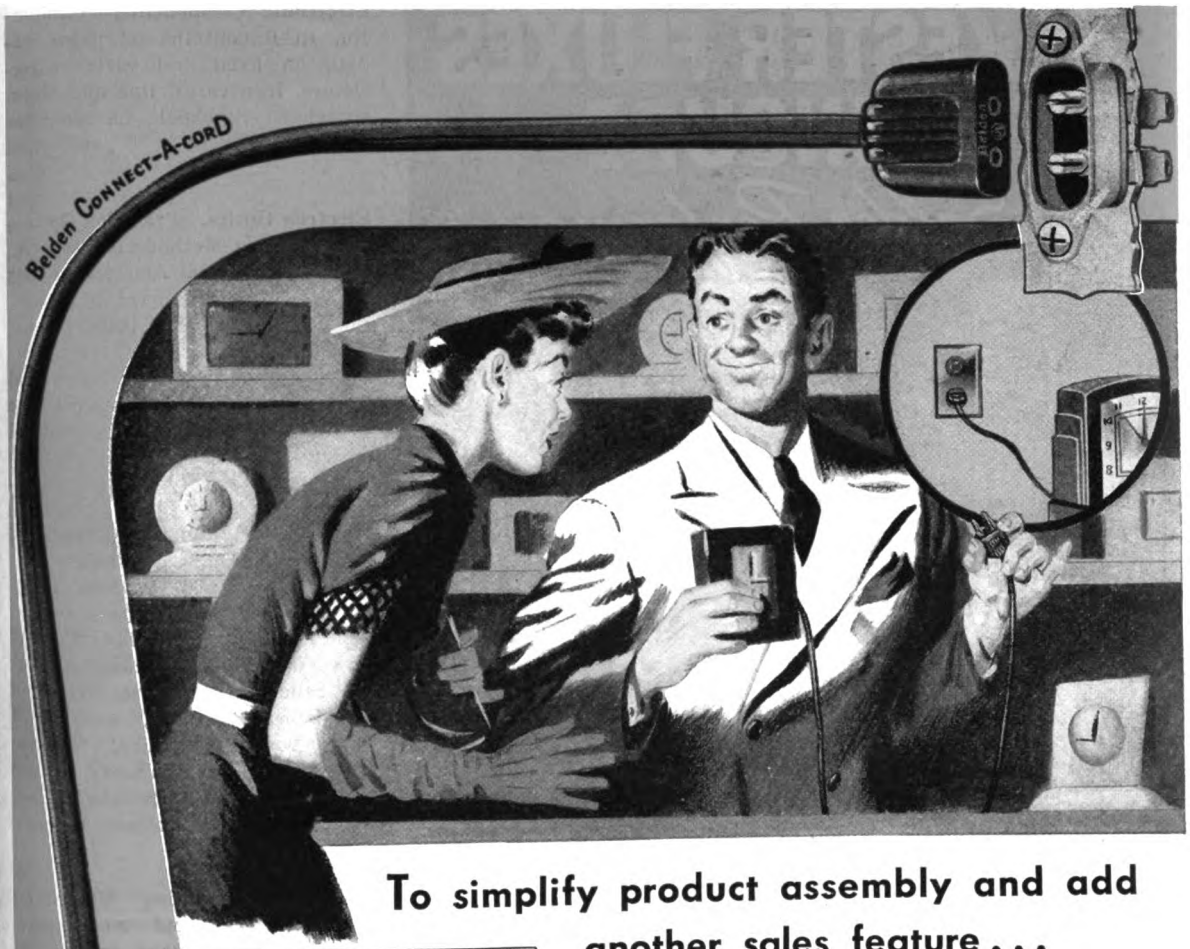

To simplify product assembly and add another sales feature . . .

THE INTERCHANGEABLE

Belden Connect-A-corD

Detachable at both plug end and appliance end and easily interchangeable, Belden Connect-A-corDs simplify assembly, packing, and display—and add another effective sales feature to your newly designed electrical appliances. Available in various lengths (and in matching colors, too), they end the nuisances of too-short-to-reach cords and unsightly tangled coils of extra lengths. And consistent national advertising pre-sells your customers on these advantages.

Need for costly dealer cord repair services is eliminated with Connect-A-corDs, and, as with all other Belden electrical cords, complete freedom from Corditis is assured. Write for complete information on the Connect-A-corD today. Belden Manufacturing Co., 4625 Van Buren St., Chicago 44, Ill.

The Belden CONNECT-A-CORD

CONNECTOR + CONDUCTOR + PLUG

A new advantage appliance users want

Though the Belden Connect-A-corD is a new idea, extensive surveys have already shown that electrical appliance users want its advantages. No mere postwar dream, it is already engineered—and it is offered now only after complete service tests and surveys to establish customer demand.

Belden

Corditis-free CORDS

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Solder Performance

Here's Why—

➡ **Kester Fluxes are *scientifically* compounded to protect your product against solder failure! No matter what type of soldering—delicate dip-soldered electrical connections, sweating operations, or various types of seams—Kester makes the right and specific flux to prepare the way for tight, trouble-free solder bonds.**

➡ **For over 46 years, Kester has been the leading name in the field of solder. Kester fluxes of highest quality and unvarying uniformity, have been perfected through laboratory research and practical experience.**

➡ **For any solder problems you may have—consult Kester engineers. They'll gladly recommend the right flux to insure the lasting quality of your product . . . and at no obligation.**

★ BUY VICTORY BONDS ★

KESTER SOLDER COMPANY

4204 WRIGHTWOOD AVE., CHICAGO 29, ILL.

Eastern Plant: Newark, N. J. Canadian Plant: Brantford, Ont.

KESTER

Solder Fluxes

STANDARD FOR INDUSTRY

Electronic Components. Catalog No. RC-6 contains 32 pages of data on fixed and variable resistors, iron cores, line and slide switches. Stackpole Carbon Co., St. Marys, Pa.

Electron Optics. Precision Optics by American Methods is the title of a booklet from American Lens Co., Inc., 45 Lispenard St., New York 13, N. Y. The booklet contains information for television set manufacturers (or manufacturers using electron optics) on optical components or complete optical systems.

X-Ray Diffraction. Two reprints from North American Philips Co., Inc., 100 East 42 St., New York 17, N. Y. include a 4-page folder from *Rubber Age* entitled, "Use of Low-Angle X-Ray Scattering in the Study of Catalysts, Viruses and Other Materials," and a 6-page booklet entitled, "X-Ray Diffraction—Basic Theory, Principles and Applications", reprinted from *Petroleum Refiner*.

Electrical Insulating Materials. The electrical and mechanical properties of various insulating materials is contained in a 4-page quick-reference folder available from Continental-Diamond Fibre Co., Newark 12, Delaware.

Aircraft Accessories. "Electro-Mechanical Aircraft Accessories" is the title of a bound data book (No. EM-200) containing approximately 225 pages. The book contains graphs, drawings and illustrations in black and white as well as three-dimensional color pictures of such equipment as linear and rotary actuators, power units, screw jacks, flexible shafting and accessories, motors and controls. Lear Inc., Piqua, Ohio.

Beryllium. A 4-page bulletin illustrates and describes Brush beryllium metal, alloys and compounds for use in x-ray transmission and sound velocity. The Brush Beryllium Co., 3714 Chester Ave., Cleveland 14, Ohio.

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A DISTINCT ADVANCE IN BRACKET DESIGN

This removable mounting bracket is now available for most G-E rectangular a-c and d-c capacitors, permitting the capacitor to be mounted upright or inverted.

1. Provides "spring-washer" effect for secure capacitor mounting.
2. Reduces strain on capacitor and chassis.
3. Compensates for manufacturing tolerances in height of case.

In contrast with the conventional L-shaped bracket, this U-bend construction minimizes the stress on the metal chassis and prevents distortion when mounting bolts are tightened. The mounting foot is sufficiently flexible to compensate for normal tolerances in height of case, and for variations in dimensions of the bracket itself.

The brackets are sufficiently thick to provide strong, rigid support. A corrosion-resistant finish of lacquered zinc plate assures a good ground from capacitor to chassis. The brackets have either one or two mounting holes depending upon the width of the capacitor.

These brackets are an exclusive feature on G-E capacitors. Spade-type and L-shaped brackets can still be obtained when desired. Ask for Bulletin GEA-4357 for information on the G-E capacitors that can now be furnished with this improved feature. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

CAPACITORS

Buy all the BONDS you can —and keep all you buy

GENERAL ELECTRIC

407-96-5700

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INDUSTRIAL CONTROL

Capacitor-Discharge Roll Welder..... 232
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Rapid Infrared Analysis..... 232
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Capacitor-Discharge Roll Welder

ELECTRONIC CONTROLS and rectifiers combine with a bank of as many as 84 120-μf capacitors to operate a newly developed roll spot welder in one of the plants of Aluminum Corp. of America. Made by Federal, the unit provides speeds as high as 300 welds per minute on sheets of 0.032-in. aluminum, and can handle thicknesses up to 0.187 in.

According to the setting of controls, 1500- to 3000-volt charges are established in portions up to the total of the capacitor bank and then dumped into the welder transformer through the action of Westinghouse electronic controls, housed in the center cabinet in Fig. 2. Rectifier and voltage-regulating gear as well as part of the capacitor bank is in this same enclosure while the remainder of the capacitors are in the right-hand cabinet. Peak power demand is 100 kva on a three-phase system.

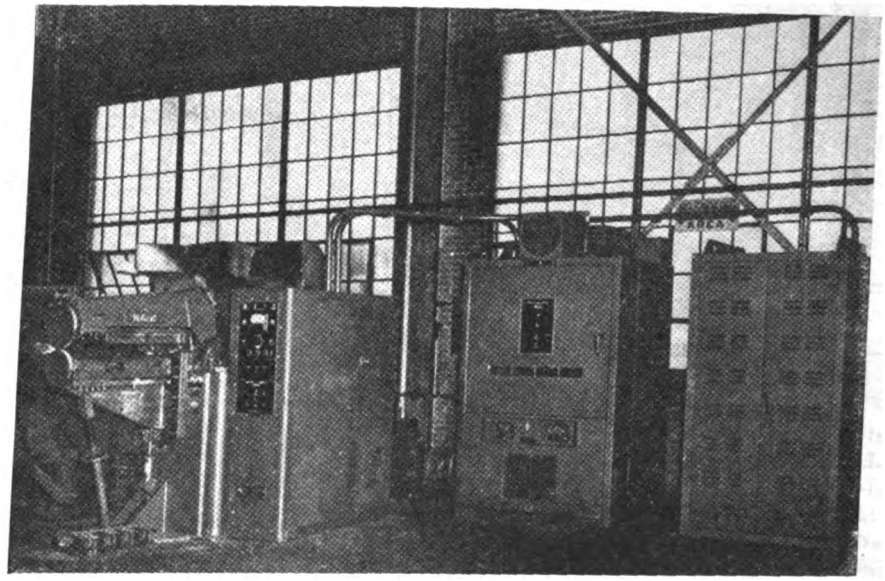

Fig. 2—Center cabinet of roll spot welder group contains main controls, rectifier, voltage regulating system, and some of the capacitors. Enclosure at right holds remainder of capacitor bank

Electronics in the Postwar Automobile

A REDUCTION of some 99.9 percent in the time required for heat-treating starter ring gears has been achieved by Studebaker Corp. with the use of electronic induction heating.

Under the old procedure, the ring gear was taken from the machining department and heated [illegible] gas oven for an hour before quenching. A draw followed to temper the body of the ring, requiring another hour and a half.

Now, an electronic heater is located in the machining department in proper manufacturing sequence. Gear teeth are brought to a specified 1500 deg within 13 seconds and

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There Is An Audiodisc And An Audiopoint For Every Recording Need

AUDIODISCS have all of the features essential to high fidelity recording. A superior lacquer is applied by a unique process that gives a flawless surface. In cutting, the thread throws well and there is no static. In playback, whether at once or in the future, there is low surface noise. Their playback life is unequalled. There are six types of AUDIODISCS:

RED LABEL tops all accepted quality standards for professional use. Double-sided in 6½", 8", 10", 12" and 16" diameters.

SINGLE FACE RED LABEL brings new economy to applications requiring but one side. 12" and 16" diameters.

YELLOW LABEL, Double-sided blanks of uniform quality and "wide latitude." Extra-fine adjustments unnecessary. Sizes as Red Label.

REFERENCE permits extreme economy in test-cuts, filing and reference recordings. Double-sided in 10", 12" and 16" diameters.

MASTERS for choice copies (pressings) after electroplating. Double or single face in 12", 13¼" and 17¼" diameters.

BLUE LABEL best discs at low cost. Thin aluminum base, same recording lacquer as professional AUDIODISCS. 6½", 8" and 10".

All AUDIODISCS are manufactured on aluminum base—and glass base too, except for the 6½" and Blue Label type.

AUDIO DEVICES, INC., 444 MADISON AVE., N. Y. C.

audiopoints

AUDIOPOINTS

Audiopoints, made by skilled craftsmen, are available in three types of recording styli and three types of playback points. Cutting and playback points are matched to give finest performance.

RECORDING POINTS

SAPPHIRE NO. 14, for professionals, designed to give proper thread throw. No finer made.

STELLITE NO. 34, professional type. Cuts quiet, shiny groove for several hours.

DIAMOND-LAPPED STEEL NO. 50, cuts a fine, quiet groove, gives from 15 to 30 minutes actual recording time.

PLAYBACK POINTS

SAPPHIRE NO. 113, finest obtainable. Complete fidelity and minimum disc wear.

BENT SHANK NO. 154, for heavy pickups.

STRAIGHT SHANK STEEL NO. 151, for light pickups.

Audio's resharpening and repolishing services give real economy in the use of **AUDIOPOINTS,** Nos. 14, 34 and 113. Consult your local dealer.

they speak for themselves **audiodiscs**

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Electronic function serves the infrared spectroscope at Westinghouse Research Laboratories. Infrared light output is converted to electrical current, amplified, and recorded on a pen-writing chart

and inserted in the unit so a beam of infrared light, produced by a heated silicon-carbide rod, is directed through it. The invisible light is conducted along a 30-ft zig-zag path by the action of mirrors and prisms, which are visible in the illustration, and ends up at a sensitive receiver which converts the light into electrical current. From there it is amplified and recorded on a pen-writing chart outside the machine.

Dips and peaks in the chart reveal the identity of materials in the sample and tell how much of each is present. Depending upon ambient temperature, molecules of each element have their own resonant frequency. Material in the sample manifests itself by absorbing infrared light at its own particular frequency. The resulting chart interprets the attenuation of a frequency as the presence of its corresponding material.

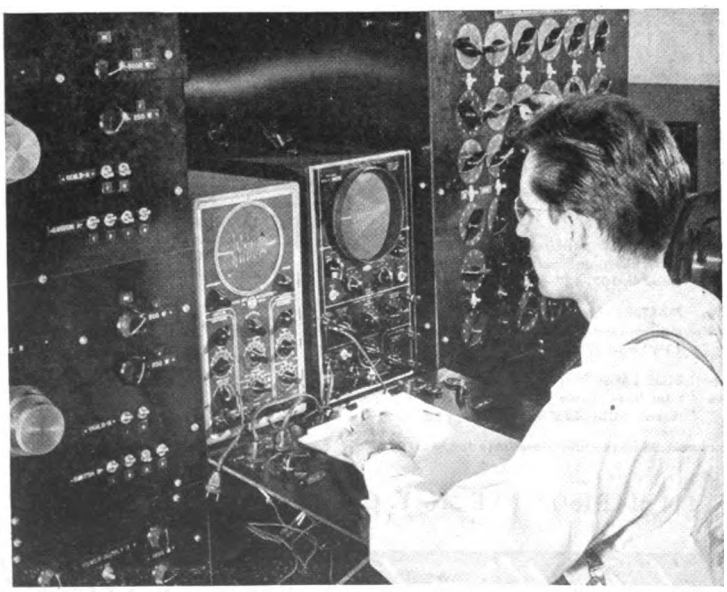
Cathode-Ray Tube Solves Production Problems

INTRICATE MATHEMATICAL PROBLEMS which might require years of ordinary calculations are solved in a few days by the mechanical transient analyzer shown here being operated by Dr. Gilbert D. McCann, who together with Harry E. Criner, developed the unit at Westinghouse Electric Corp.

Originally designed to meet new problems in the design of turbo-generator units, the analyzer has been pressed into service on such diverse calculations as those involved in vibration studies on ship propulsion equipment and the mechanics of packing electron tubes against damage in shipment.

Electrical counterparts are assigned to all the mechanical factors involved in a problem, circuits are connected in appropriate sequence and transient impulses are applied by rotating mechanical switches. The solutions are written on cathode-ray screens of conventional oscilloscopes.

"Engineers have long recognized a relationship between mechanical and electrical systems," says Dr. McCann, "but the development of apparatus to carry through these relations for a practical purpose has been a stumbling block to their full use." The particular development which made the new analyzer possible is a specially constructed low-loss inductance which permits the representation of mechanical systems with extremely low damping.



Cathode-ray oscilloscopes provide the answers to mathematical problems in new Westinghouse analyzer

Electronic Fuel Gaging

MINIMIZING ERROR and increasing reliability are two of the main achievements of a capacitor-type electronic fuel gage designed for

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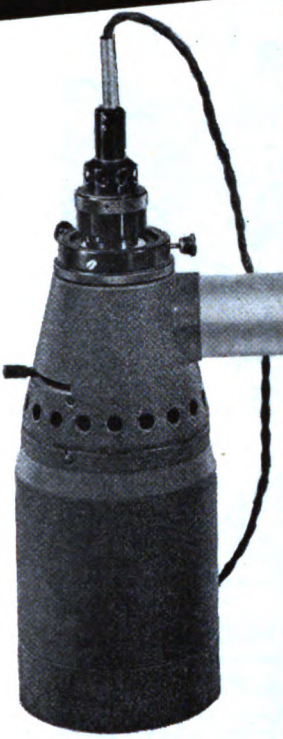
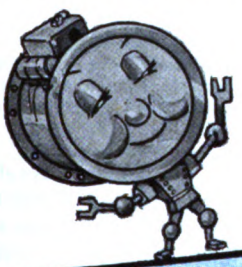
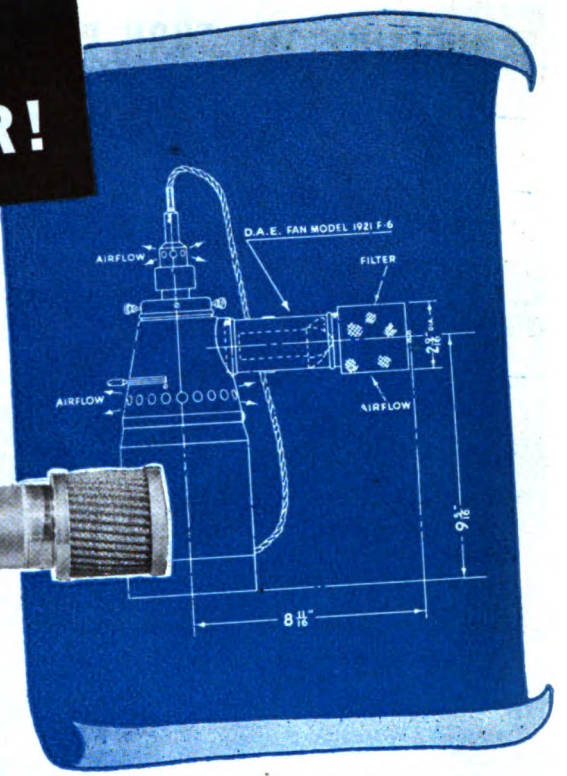
ADAPTATION IS A PUSHOVER!

PROBLEM

To cool the portable projector to a maximum temperature rise of 35°F on the case surface, and to filter inlet air, eliminating dust from the air stream to keep multiple lenses clean. Current available: 20-23 V., D.C.







QUICKLY SOLVED

Dynamic Air Axial Flow Blower **No. 1921F-6 (2″ diameter), with an aluminum mesh filter, delivers 10 C.F.M., net, through the projector . . . and holds temperature rise to 15°F. Total weight of fan and filter, 10 oz.**

DYNAMIC AIR AXIAL FLOW BLOWERS—ENGINEERED TO SAVE SPACE, WEIGHT AND HORSEPOWER — ARE BEING USED FOR:

Electronic tube cooling
Airplane heating
Warm air furnaces
Oil burners
Stokers
Refrigeration locker plants
Quick freeze units
Trains and buses
. . . and for many other types of equipment requiring blowers.

GENERAL SPECIFICATIONS

24/28-V D.C.	1/500 to	4 h.p.
115-V D.C.	1/100 to	4 h.p.
115-V A.C.	1/100 to	½ h.p.
400-cycle A.C.	1/500 to	1 h.p.

Prototypes Available

Once the facts of the problem were known, adaptation of a Dynamic Air Axial Flow Blower and a Dynamic-designed heating unit to deliver the correct air flow at the required temperature rise was a "pushover" for Dynamic's experienced air engineers! This problem is typical of help they are giving in many fields—for both war and postwar needs.

Pioneered by 14 years' laboratory and field development work, Dynamic's Axial Flow Blowers are the most advanced application of the "air delivered in a straight line" principle . . . with a big saving in space, weight and horsepower input.

If you have an air movement problem in connection with present or projected equipment, take advantage of Dynamic's long experience in solving difficult blower problems . . . *write or wire today!*

DYNAMIC AIR ENGINEERING Inc.
LOS ANGELES, U. S. A.
DESIGNERS and BUILDERS of HIGH EFFICIENCY AXIAL FLOW EQUIPMENT

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Yes! linear to within 1/10th of 1% — the climax of long experience and accumulated "know-how" in precision engineering. This accuracy is *guaranteed* in the GIBBS MICROPOT, the new 10-turn Potentiometer.

In this remarkable unit resistance is directly proportional to shaft rotation through a full 3,600 degrees . . . within plus or minus 10 ohms in a 10,000 ohm unit. Such results are obtained by precision manufacturing and engineering knowledge.

Constant stability of resistance and linearity is assured through the fact that the resistance element, with both end terminals soldered in place, is moulded as an integral part of the instrument housing. There can be no loosening or shifting of the resistance wire. . . . Thousands of these GIBBS MICROPOTS are proving their built-in long life qualities — many being used in radar operation.

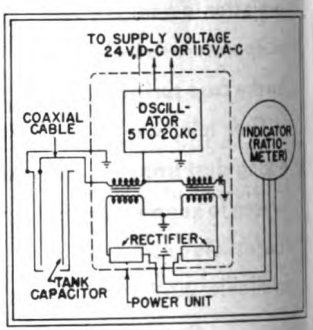
In stock and available now are units of 1,000 to 30,000 ohm range. If required, special resistance values can be made to order. If you have a particular problem, our specialists will be glad to consult with you at any time. Write today for engineering specifications.

MICROPOT
GIBBS
THOMAS B. GIBBS & CO.
DIVISION OF THE GEORGE W. BORG CORP.
DELAVAN, WISCONSIN

aircraft use and shown in the accompanying illustration. The components of the system include a capacitor sensing unit, a power unit, and a cockpit indicator.

As shown in the circuit diagram, the unit contains an oscillator section consisting of a single-tube oscillator that generates a frequency of approximately 10,000 cps.

The output frequency of this oscillator is impressed on two parallel circuits, each containing a capacitor and an inductor. As shown, one of the capacitors is the tank unit whose capacitance varies as a function of the depth of fuel in the tank—its dielectric changes from 100 percent fuel to 100 percent air by intermediate stages as the fuel level is varied.



Circuit of gage that measures fuel to within three percent accuracy over all ranges of temperatures. Oscillator section consists of a single-tube generator

The other capacitor is fixed and serves as a reference for the variable capacitor. The cockpit gage takes the form of an indicating instrument reading the ratio between the rectified output of the fixed and variable circuits. The a-c voltage going to the rectifier on the variable side changes in ratio with the fuel level plus variations in the voltage and frequency from the oscillator. However, since the fixed side also exhibits the latter variations, the final ratio is independent of such irregularities.

The circuit designed by Simmonds Aerocessories, Inc., of New York, is such that accuracy of indication is maintained within one percent upon the replacement of any tube in the power unit. Failure of the tube will affect only one circuit.

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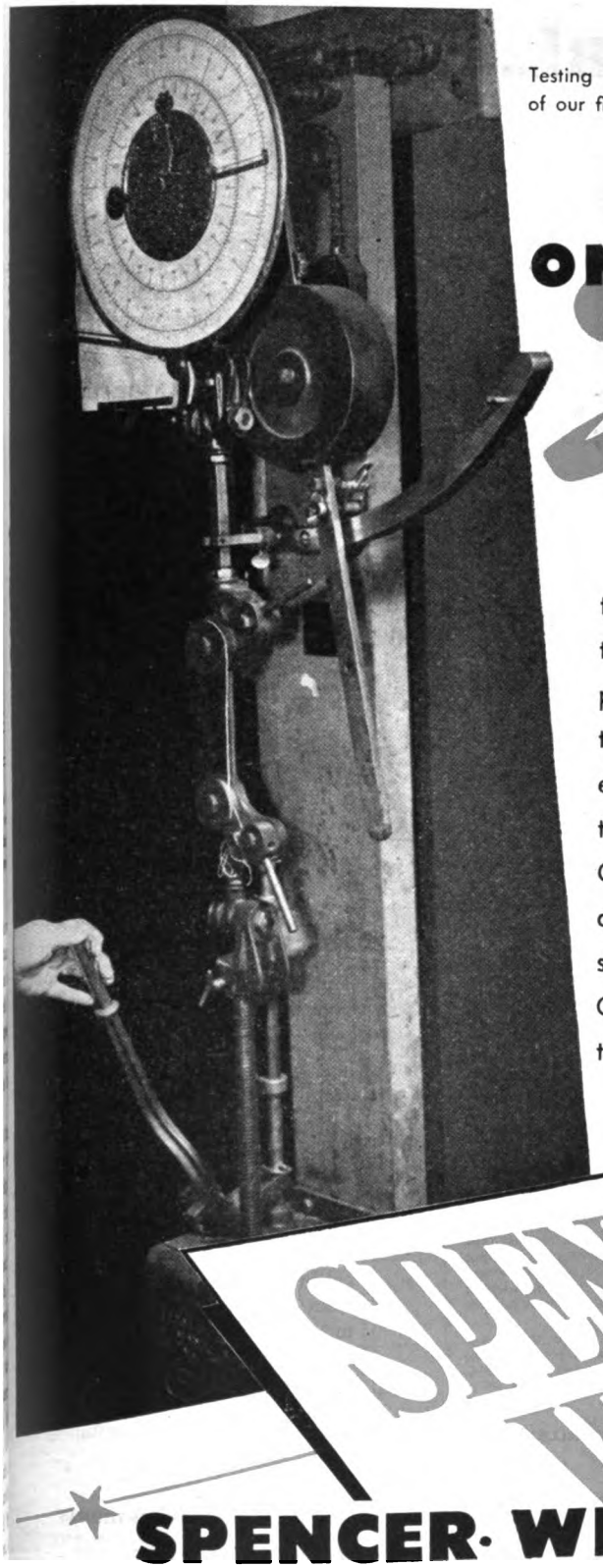

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A necessity wherever dependable voltage measurements within the range of 7 cps to 500 megacycles are required—the Televiso Series 200A VT Voltmeter is highly accurate and stable. IMPORTANT WAR TIME DEVELOPMENTS ARE AVAILABLE FOR THE FIRST TIME IN THE FOLLOWING FEATURES:—

SUPERSENSITIVE RANGE—the lowest readable voltage is .05 volts on a maximum scale range of .5 volt.

FIVE VOLTAGE RANGES—.5, 2, 15, 50, 150—spread full scale on a 4½" meter dial for easy reading. Accuracy of readings are 2% full scale; middle scale accuracy is 5% or better.

PROBE CONSTRUCTION—detachable probe to eliminate cable wear; easily dismantled for tube replacement or for soldering to tube terminals for measurements in the 250-500 MC region; flat ½" wide brass terminals connect to input to make easy soldering to test or work piece; for low frequency work up to 100 MC, removable banana plugs are spaced ¾" center to center for use with standard jacks.

MECHANICAL CONSTRUCTION—of aluminum throughout; panel and cabinet are ¼" thick (cabinet is dural); sub-chassis is ⅛" and spaced off the panel by studs to simplify servicing; all components are fastened to sub-chassis.

ELECTRICAL CONSTRUCTION AND CIRCUIT—Series 200A utilizes the finest components throughout and carries a two year guarantee. The circuit is a stable plate circuit rectifier. No diode input tube is used. The plate circuit rectifier type makes available higher input impedance at all frequencies. No shortening of input probe is required for zero adjustments. All zero adjustments are made once and remain constant. A panel adjuster is available to make the unit usuable without heating up time. All filament and plate voltages are transformer and tube regulated.

BUILT-IN CALIBRATION VOLTAGE—All units have a jack which produces a constant 6.3 volts for standardizing. This is the regulated filament voltage. The sensitivity can be adjusted without tools in the event tubes are replaced in the field. The Series 200A will operate satisfactorily from any source of voltage from 95 to 130 volts ac. Line voltage surges are not observable during use.

SIZE—14"H x 9½"W x 7½"D. Guaranteed 2 years. Price $170.00 F.O.B. Chicago.

TELEVISO PRODUCTS CO.

7466 IRVING PARK ROAD CHICAGO 34, ILLINOIS

thus only one indicator reading. Failure of the tube causes the indicator to read off scale.

Four types of sensing units for tank mounting are provided. They include a flange type as shown in the illustration, a non-flange type which mounts by bolts to the inner walls of fuel tanks, a quick-assembly type held in self sealing tanks by cemented synthetic end-fittings, and

Capacitor-type electronic fuel gage is composed of tank unit, power unit, and cockpit indicator. Coaxial cable is used between tank and electronic section in power unit. No. 22 wire to indicator

a stiffener type which serves as a structural member of the tank in addition to its sensing element functions.

Power units are supplied for use with d-c or a-c power supply—d-c units approximating 1¾ lb per indicator and a-c units running a little more.

Indicator

Cockpit gages are available in single and dual 100-deg arc types and small and large 250-deg units. Absolute adjustment for full and empty are made directly on the indicator, permitting calibration by a single individual. It is recommended that indicating gages be calibrated in weight of fuel rather than liquid measure, since this is more accurate. Junction transformer heads are used for multiple-tank unit installations as a means of hooking up inner and outer tube connections so that capacitances can be added.

• • •

High-speed Components Tester

SUITABLE FOR THE high-speed testing of capacitors and inductors, the circuit of an electronic limit bridge shown below utilizes a pair of 6E5

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former heads are used
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High-speed Compu
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SUITABLE FOR THE
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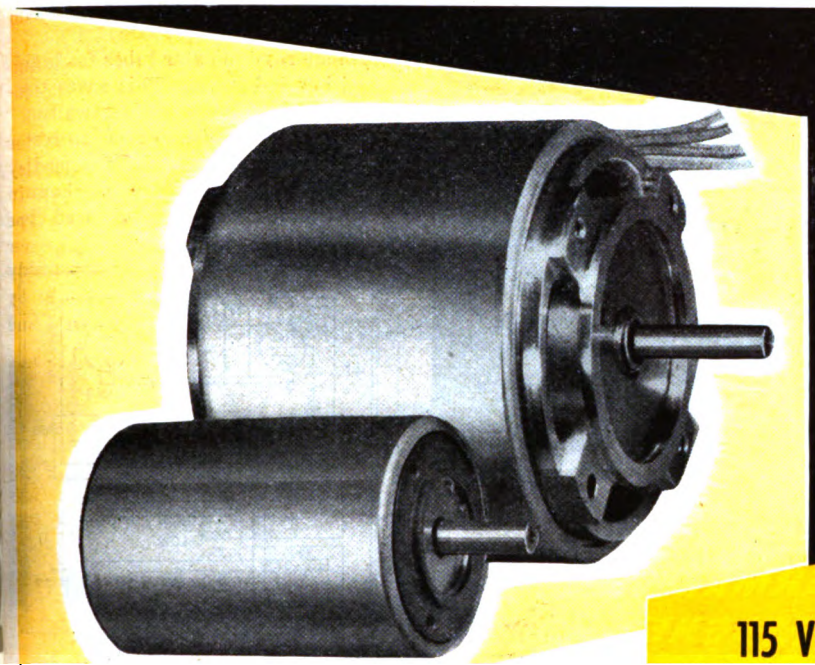
circuit of an electron
shown below utilizes

December 19



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CAPACITOR INDUCTION MOTORS	3-5/16" Diam. Frame				
Capac. Start & Run	1/15	3000	Int.	Sealed Ball bearings	K70F K71F
" " "	1/30	3200	Cont.	" "	K70B K71B
" " "	1/60	3300	"	" "	K70 K71
" " "	1/15	3000	Int.	Sleeve	K73F
" " "	1/30	3200	Cont.	"	K73B
" " "	1/60	3300	"	"	K73
SHADED POLE MOTORS	3-5/16" Diam. Frame				
Shaded Pole	1/50	1420	Int.	Sealed Ball Bearings	KP70F KP71F
" "	1/100	1530	Cont.	" "	KP71 KP70
" "	1/50	1420	Int.	Sleeve	KP73F
" "	1/100	1530	Cont.	"	KP73
SYNCHRONOUS MOTORS	3-5/16" Diam. Frame				
Capac. Start & Run	1/100	1800	Cont.	Sealed Ball Bearings	JS70 JS71
" " "	1/100	3600	"	" "	KS70 KS71
" " "	1/100	3600	"	Sleeve	KS73
CAPACITOR INDUCTION MOTORS	1¾" Diam. Frame				
Capac. Start & Run	1/100	3000	Int.	Ball Bearing	K49F
" " "	1/250	3150	Cont.	" "	K49
" " "	1/100	3000	Int.	Sleeve Bearing	K43F
" " "	1/300	3150	Cont.	"	K43

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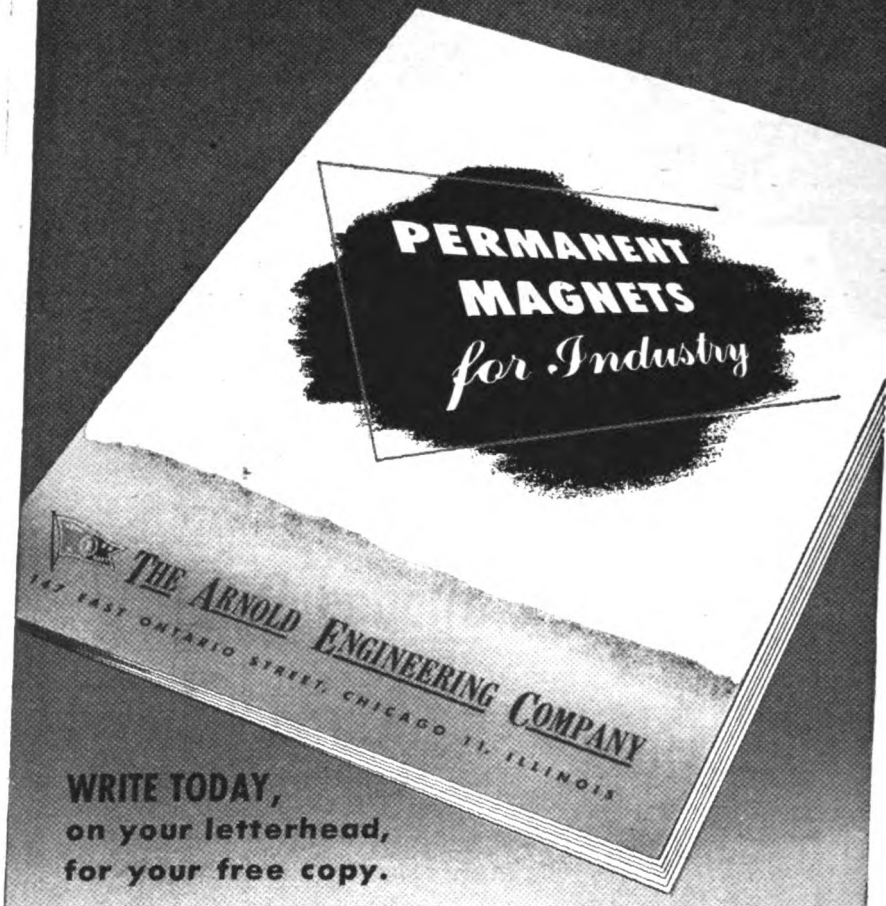

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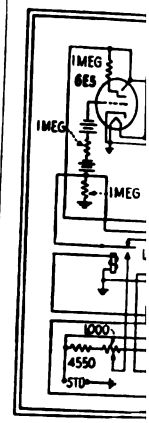

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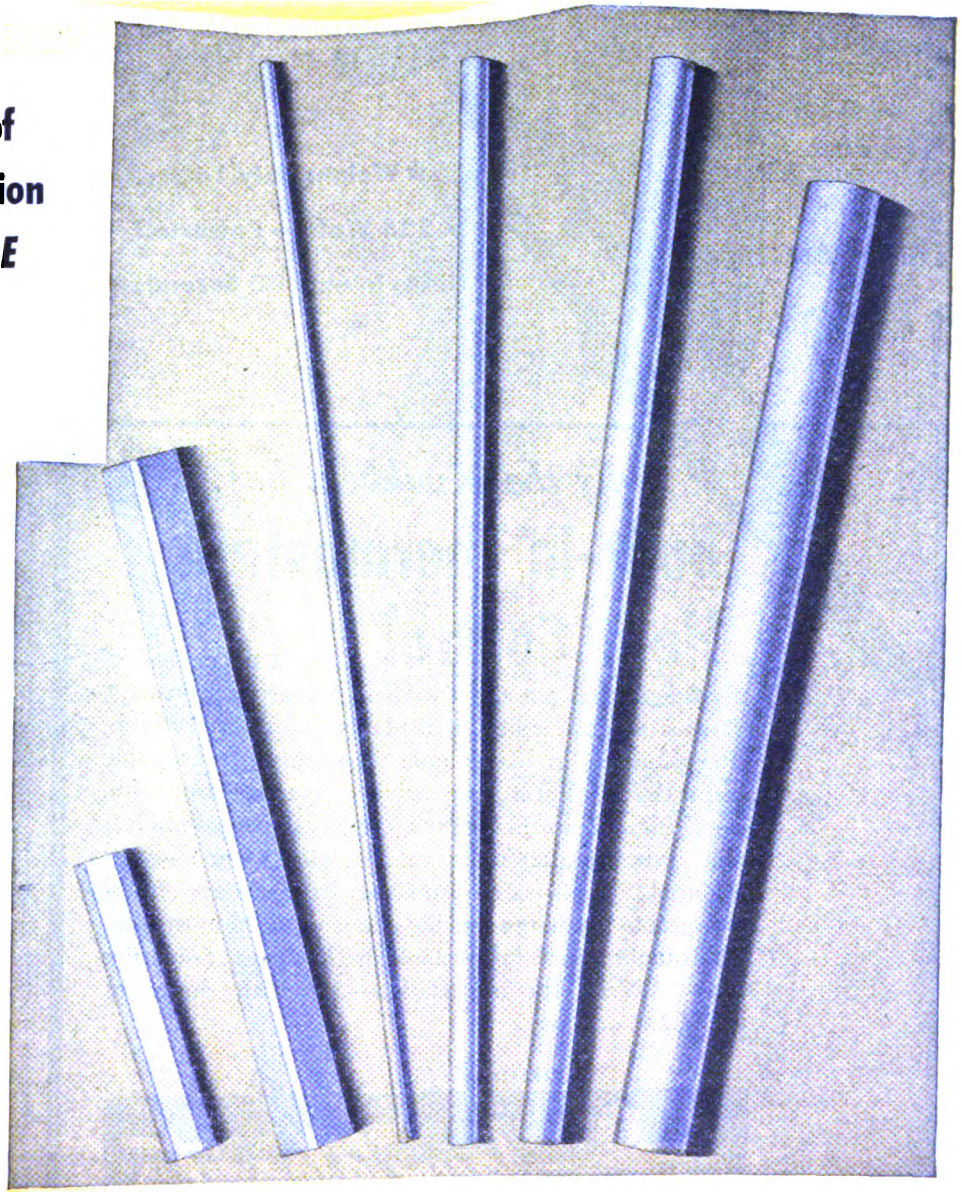

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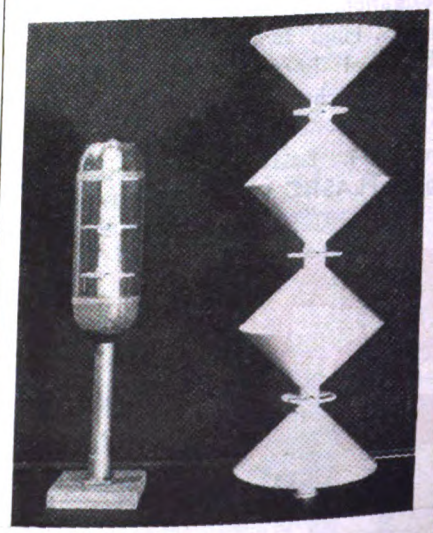
APPLICATION of nearly superhigh frequencies to railway communication has been announced by the Chicago, Rock Island Railroad. The system now being installed on the Chicago Division was developed as a result of experimental work conducted by E. A. Dahl of the Rock Island and H. H. Willis of the Sperry Gyroscope Co.

Communication between engineer and conductor is provided by transmitters and receivers equipped with press-to-talk hand sets, installed in



Two of the antennas used in experiments conducted on 2660 mc for railroad radio

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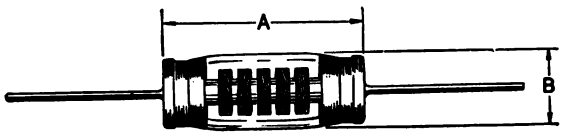

MILLI-HENRIES	A	B
1.0	1-3/4"	5/8"
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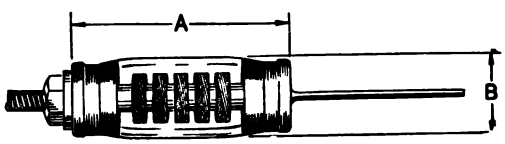
2.5	2"	5/8"
5.0	2"	11/16"
10.0	3"	11/16"



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Microwave (2660-mc) transmitter and receiver developed by Sperry Gyroscope Co. engineers. The liquid-cooled klystrons at far left multiply ten times to produce the final frequency

crystal controlled oscillator. This is trippled twice, doubled and tripled again before being fed to a klystron frequency multiplier that raises it ten times to the carrier frequency.

Specially designed antennas, fed by stub-supported concentric lines, concentrate the radiated power into a pancake-like field. Consistent results have been obtained in practice where the trains were operating in tunnels or in deep gorges.

• • •

Ship-search Radar for Troopships

SAFE AND SPEEDY return of servicemen from overseas is the objective of a current program of installing ship-search radar equipment on transport vessels. All new bottoms as well as those not previously so equipped are having Models SO-1

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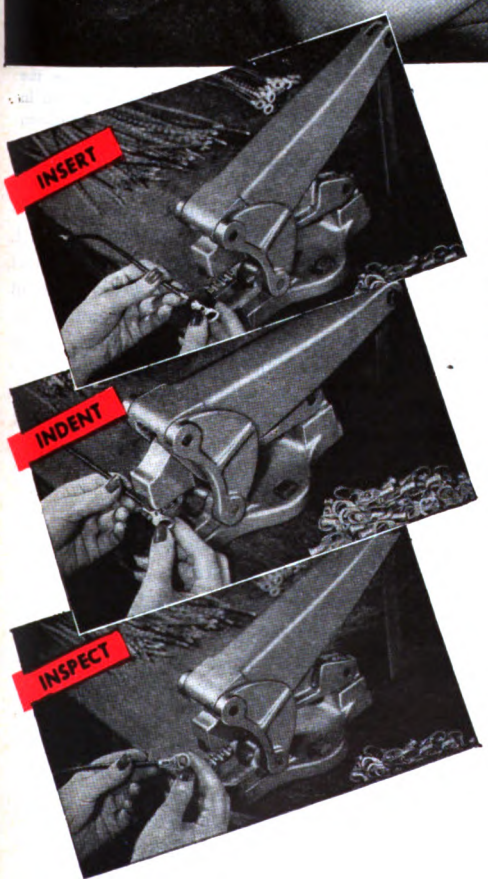
FOR SMALL OR LARGE QUANTITIES!



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Simple, compact, and relatively inexpensive, the Burndy HYTOOL (Cat. No. Y10R) provides new economies in making small wire connections . . . *regardless of quantities.*

In addition, each connection made is uniformly high in *mechanical strength* and *electrical efficiency* . . . because of the Burndy indent method, and Burndy's one-piece, pure-copper connector design. Here are the outstanding features of this HYTOOL:

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4. Economical for short runs . . . high production and low-cost on long runs.
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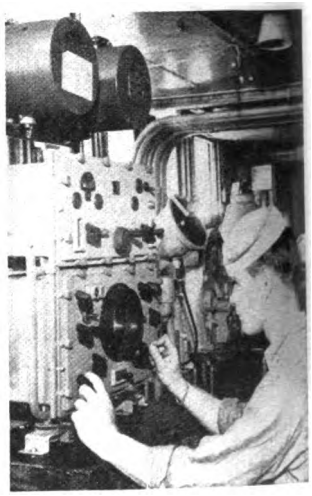
and SO-8 radar put in by Raytheon field engineers assisting Navy supervisors. That company has been the sole producer of both SO and SG microwave radars.

The SO type is a small modified version of the SG which finds a place on all combatant ships of the U. S. Navy. The SO system has been applied to thousands of land-



Installation of a type SO radar in the pilot house of a troopship is shown in this Signal Corps photograph. Raytheon gear of this model is being installed in troopships for speedier ocean crossings

ing craft, PT boats, attack transports, auxiliaries, and patrol craft.

As used in the present transport of troops, the gear saves time in the ocean crossing because the ships' speed does not have to be reduced in fog or darkness, collisions and delays are eliminated, and the vessels can get in and out of ports regardless of weather or the time of day.

• • •

High-Frequency Aircraft Ignition System

THE SCHEMATIC DIAGRAM shows a high-frequency aircraft ignition system which was successfully flown last year on one engine of an AAF B-24 bomber at Vandalia, Ohio. Further tests are being made on B-24's at the Smyrna Army Air Base, Smyrna, Tenn.

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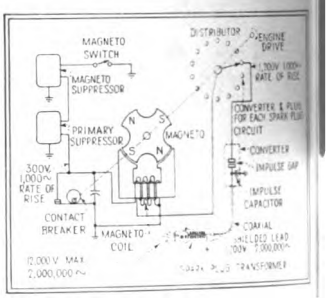
fold ring into r-f at two to three million cps by an impulse-type frequency converter, delivered to the spark plug through a shielded coaxial line, and there transformed to about 10,000 volts for firing the plug. The final voltage step-up is performed in a small transformer sealed hermetically into the well of a standard aircraft spark plug.

The energy produced in this system has such a steep wave front that it is capable of igniting a cylinder charge despite fouled, leaded, or carbonized plugs, conditions which often arise from long periods of



Circuit diagram of the high-frequency aviation ignition system. It will fire a spark plug shunted by 10,000 ohms resistance

idling, taxiing, or gliding. Inability of the pilot to get full power from the engine immediately under these conditions frequently causes forced landings. In tests, this circuit was able to fire plugs against a shunt resistance of 10,000 ohms where conventional systems begin to miss at 100,000.

Other advantages include increased engine output as a result of the possibility of using colder spark plugs without fear of misses from fouling; good high-altitude operation because of low-tension distribution; increased spark plug life since gap erosion is reduced by the low energy level; substantial reduction in radio interference; and a saving of 10 lb or more per engine.

Because the major portion of work to date has been directed to engines for large military aircraft, the possibilities for small personal planes and automobiles have not been explored as completely. However, the indications are that there may be many useful functions for

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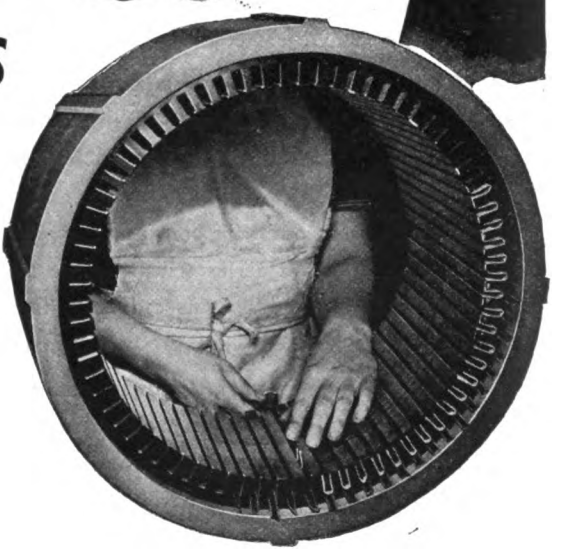

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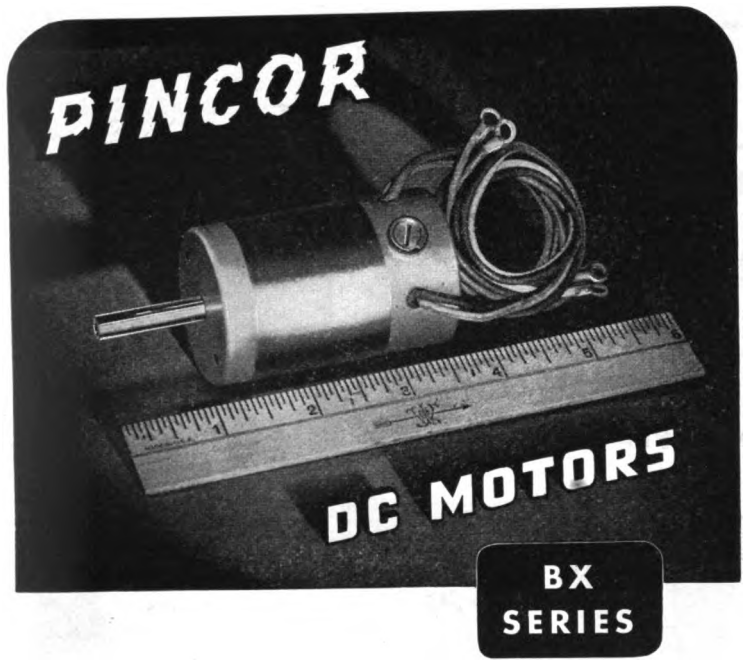

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high-frequency ignition systems.

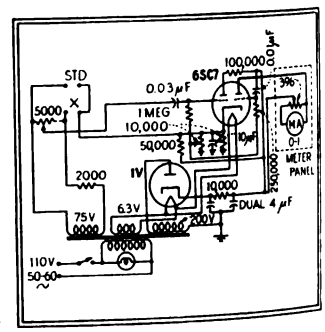
The development was derived from work done previously by Fred J. Hooven of Dayton, Ohio and was performed by P. R. Mallory & Co., which has concluded licenses with American Bosch Corp. and the Scintilla Magneto Division of Bendix Aviation Corp. with others under discussion for further development and manufacture.

• • •

Direct-indicating Comparison Bridge for Production Testing

DESIGNED FOR RAPID production testing where moderate accuracy is desired, the circuit shown in the illustration provides comparison of resistors, capacitors and inductors to a similar standard. It consists of an a-c slide-wire bridge and an electron-tube indicating circuit. The slidewire covers a range of approximately ±50 percent of the value of the standard.

Three working standards are used in calibration of the gear: one of nominal value and one each of upper and lower desired limits. Low and high values can be different. After adjustment, the separate indicating meter provides a within-limits reading up to a marked point on the scale or an outside-limits reading beyond. Thus the testing operator is not required to rotate dials or press buttons.



Schematic diagram showing use of type 1-V rectifier and 6SC7 null indicator in direct-indicating comparison bridge

Accuracy of the equipment is largely dependent on the care with which limits are set as well as variations in line voltage. However, sensitivity and stability are such

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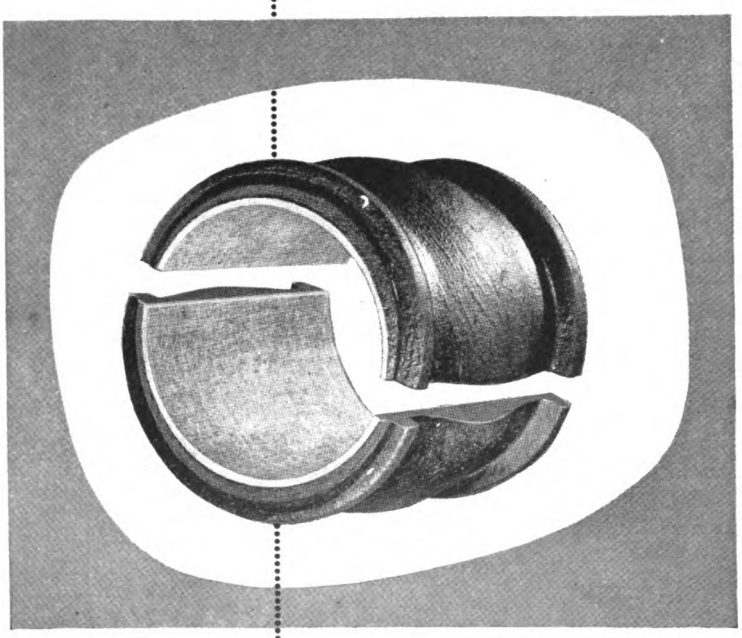

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as to permit successful operation with limits set as close as ±5 percent or as wide as ±50 percent of nominal. As made by Industrial Instruments, Inc., the range of measurement on capacitance is from 0.0001 to 1.0 μf; in resistance, from 2000 ohms to 20 meg; and in inductance, from 5 to 50,000 henrys.

• • •

Selsyn Indicating Systems for Remote Readings

BY F. WISK

Long Branch, N. J.

INDICATING SYSTEMS that provide readings remote from the scene of operations have found wide application in industry during recent years and have been used in many military equipments. In such systems, selsyn motors provide a convenient and flexible means of remote electrical position indication. A basic indicating system consists of a transmitter and receiver, with both units being electrically identical. The transmitter rotor is driven by external mechanical means and the receiver, at a remote point, indicates the position of the transmitter rotor. To understand the theory of operation of selsyn indicating systems a review of basic theory of the principles involved is in order.

Action on D-C and A-C

Referring to Fig. 1, coils *A* and *B* are placed in close proximity to each other. Assume that coil *A* is held in a stationary position and coil *B* is light and free to move if a force is exerted. If switch *S* is closed momentarily, a current will flow in coil *A* which in turn will be induced in coil *B*. Since the induced current in coil *B* will flow in the opposite direction to coil *A*, like magnetic poles will be set up as indicated and coil *B* will be repelled by coil *A*.

Referring next to Fig. 2, coil *A* is connected to a source of alternating current and creates induced current in coil *B* at the same frequency. The induced current in coil *B* is opposite in direction to coil *A*, hence in Fig. 2 coil *B* will be repelled by coil *A*. Although the magnetic poles of coils *A* and *B* are rapidly reversing they will still be opposing.

In Fig. 3 first assume that the

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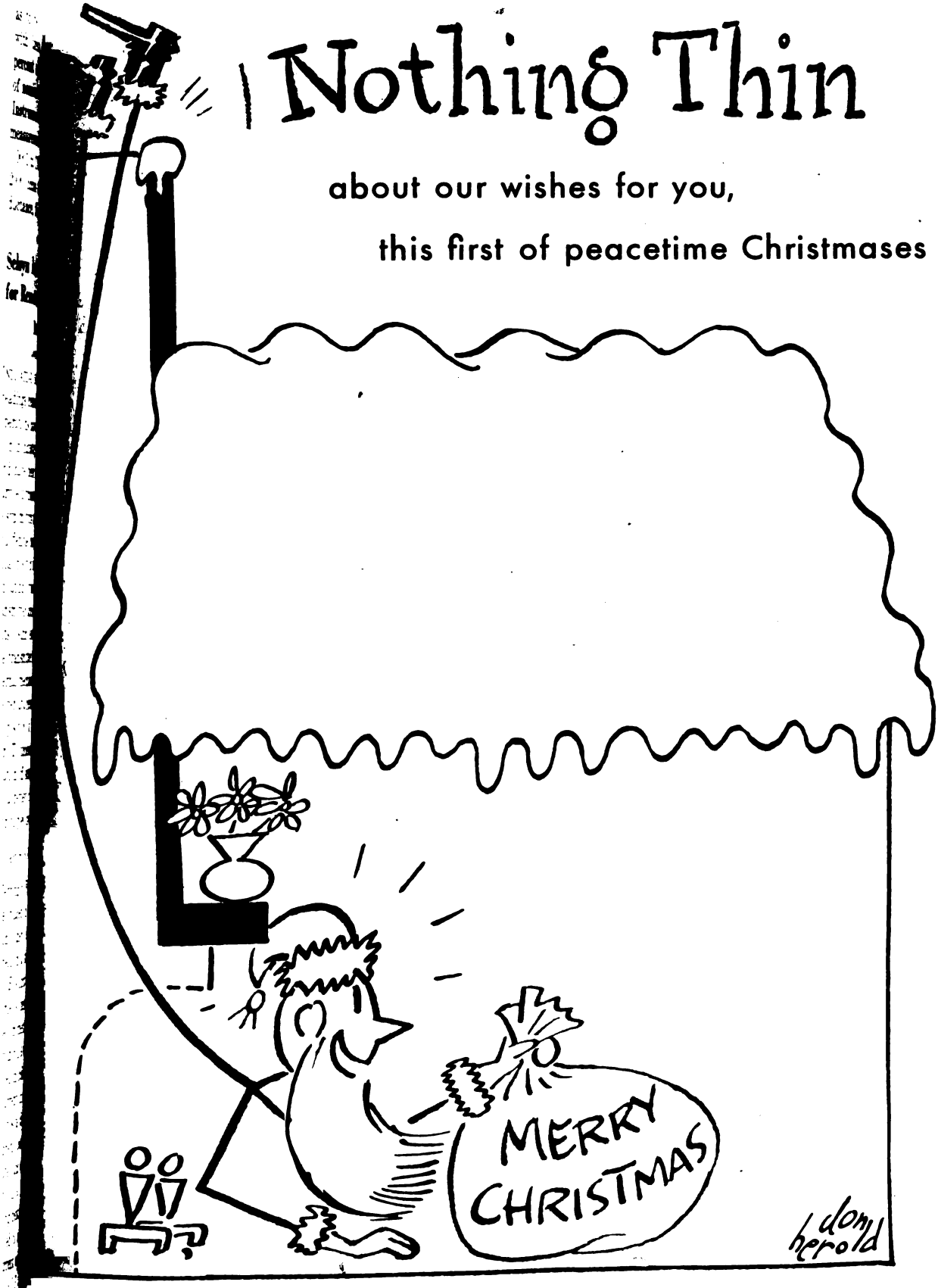

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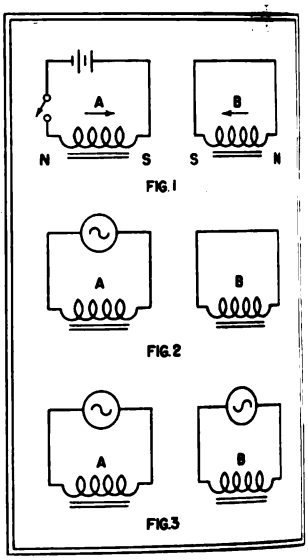
Write for descriptive technical Bulletin 8

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY, U. S. A.

generator across coil *A* is operating and that the generator across coil *B* is turned off. Under these conditions, the same situation exists as in Fig. 2; coil *A* will repel coil *B*. If the generator connected across coil *B* is then used to supply current that is out of phase with



Figures 1 to 3 show the elementary steps in analyzing the operation of a selsyn indicating system

the induced current, enough current can flow in coil *B* to cancel the induced current and the coils will not repel or attract.

If the generator is adjusted to supply coil *B* with more current than the induced current, the magnetic poles of coil *B* will be reversed and the coils will attract, since the poles of coil *B* will then be reversed.

Principles

To summarize the action (Fig. 3), three important conditions exist:

1. With the generator supplying coil *A* operating, and the generator connected across coil *B* off, coil *A* will repel coil *B*.

2. With both generators operating and the generator across coil *B* supplying sufficient current to cancel the induced current in coil *B*, the coils will not repel or attract.

3. If the generator across coil *B* supplies a larger (out of phase

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current than the induced current, the coils will attract.

While in actual construction selsyn motors are of multi-stator winding design, for purposes of explanation one-, two-, and three-stator windings will be used.

In Fig. 4, rotors R_1 and R_2 are connected in parallel across a source of a-c. Stators S_1 and S_2 are connected in parallel. In the neutral position as shown, the coupling between R_1-S_1 is equal to that between R_2-S_2, hence the induced voltage across S_1 and S_2 will be equal. Since S_1 and S_2 are connected in phase opposition the induced currents will cancel, hence there is no attraction or repulsion. In Fig. 5, the transmitter rotor R_1 has been turned clockwise about 45 degrees, the coupling between S_2-R_2 is now tighter than S_1-R_1, thus the induced voltage across S_2 is now greater than across S_1. Current will now flow from S_2 to S_1. This current flow is due to induced current, (R_2 to S_2), hence

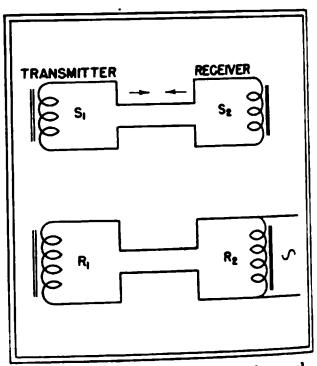

FIG. 4—When the coupling is equal, currents induced in S_1 and S_2 cancel

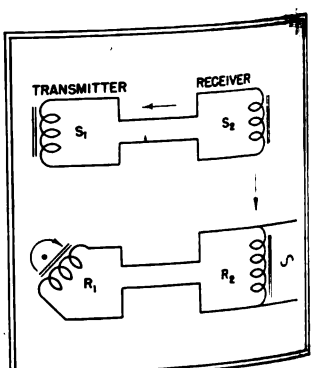

FIG. 5—Turning rotor R_1 produces a higher voltage across S_2 than across S_1

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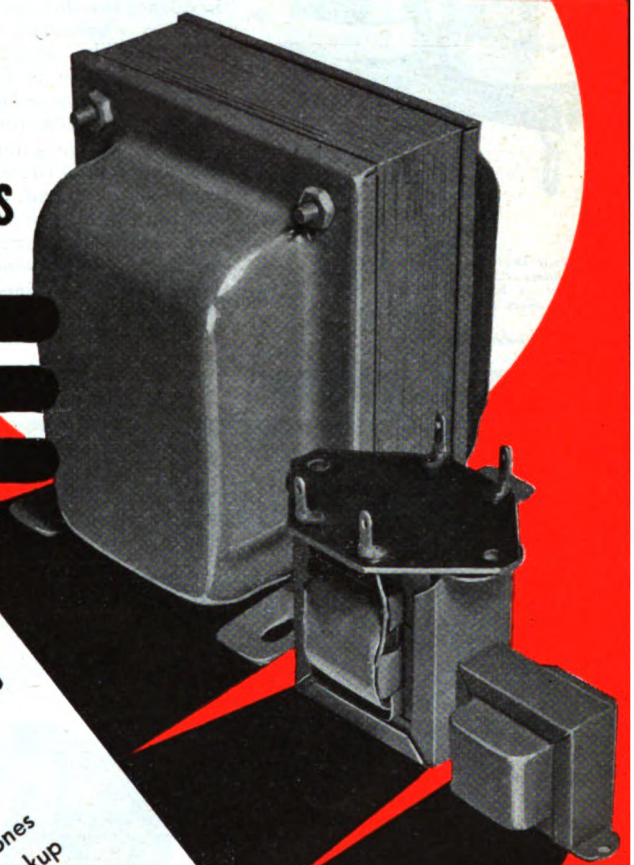

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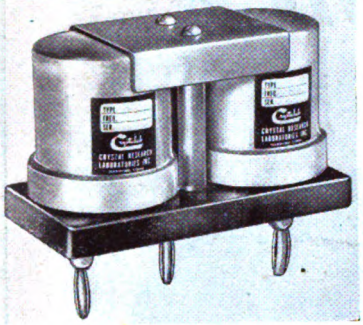

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S_2 will repel R_3. Since S_3 is stationary and R_2 is free to move, rotor R_2 will turn until the voltages across S_1-S_2 are equal (same degree of coupling), thus R_2 will rotate 45 degrees.

Neutral Position

Referring next to Fig. 6, rotors R_1 and R_2 are coupled with stators S_1, S_2, S_3 and S_4 in neutral position as shown; the degree of coupling between R_1-S_1 and R_2-S_3 are equal and the coupling between R_1-S_3 and R_2-S_4 are also equal. The degree of coupling of R_1-S_3 and R_2-S_4 is less

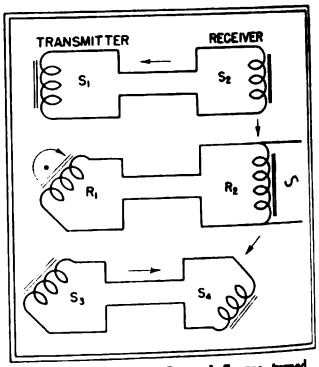

FIG. 6—If stator S_3 and S_4 are turned to the same angle, there is no movement of the rotors

than R_1-S_1 and R_2-S_2, hence the induced voltages across S_3-S_4 will be less than across S_1-S_2, however, in the neutral position as shown in Fig. 6, the voltages across S_3-S_4 are equal and opposite, likewise the voltages across S_1 and S_2 are equal and opposite even though higher. Since the voltages across the respective stators cancel, no movement of rotor R_2 takes place.

In Fig. 7, transmitter rotor R_1 has been displaced 45 degrees, the coupling between R_2-S_3 is now tighter than R_1-S_1 hence current will flow from S_2 to S_1. As this current flow is due to induced current from R_2 to S_2, stator S_2 will repel rotor R_2. The coupling between R_1-S_1 is tighter than the coupling R_2-S_4 and the voltage across S_3 is greater than across S_4. Current therefore will flow from S_3 to S_4. The currents across the rotors are out of phase and the current from S_3 will predominate as it is of greater magnitude. Rotor R_2 will now be attracted by stator S_4. In the position shown

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S_1 will repel R_1. Since ... ary and R_1 is free to ... R_1 will turn until the ... S-S_1 are equal and ... coupling is, thus R_1 ... degrees.

Neutral Point

Referring next to ... R and R_1 are coupled ... S, S_1, S_2, and S_3 ... as shown; the degree ... between R-S and R_1-S_1 ... and the coupling between ... R_1-S_1 are also equal. The ... coupling of R-S_2 and R_1-...

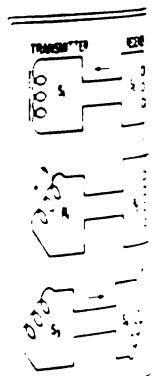
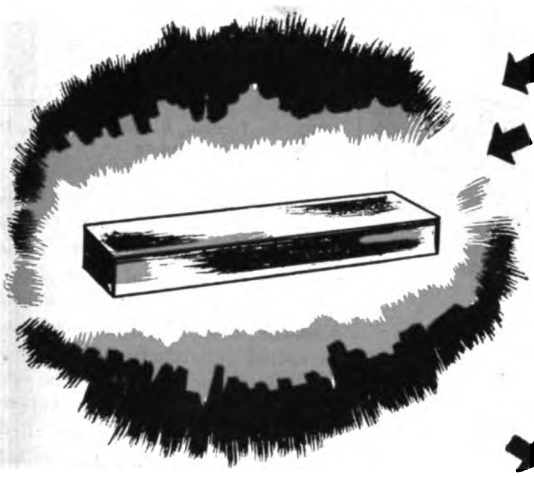


FIG. 6—If stator S_1 and ... to the same couple, then ... center of the ...

than R-S and R-S_2 ... duced voltages across ... less than across S-S_2, ... the neutral position ... Fig. 6, the voltages ... equal and opposite ... voltages across S and ... and opposite even ... Since the voltages across ... five stators cancel, ... rotor R_1 takes place.

In Fig. 7, transmitter ... has been displaced 45 ... coupling between R-S ... tighter than R-S ... will flow from S to ... rent flow is due to ... from R to S_2 stator ... rotor R_1. The coupling ... is tighter than the ... the voltage across ... across S_2. Current ... flow from S_2 to S ... across the rotors ... and the current ... dominate as it is ... rade. Rotor R_1 ... by stator S_2. In the ...

FROM FURNACE TO ICE BATH . . . *instantly*



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DIMENSIONAL STABILITY OF INVAR! The low thermal expansion coefficient of this recently developed General Ceramics product is within the same range as that of invar.

These unusual properties of M-244 suggest its use in high temperature furnaces, high frequency induction heating units, thermo-couple insulation, and as insulation in vacuum tubes . . . for scores of other uses where thermal shock is a factor . . . where dimensional changes of insulation due to heat changes must be absolutely minimized.

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INFORMATION AVAILABLE. General Ceramics and Steatite Corporation offers the services of its design, engineering and research staffs to help industry explore and exploit the vast potentialities of versatile M-244. Write for technical data.

ARMY E NAVY

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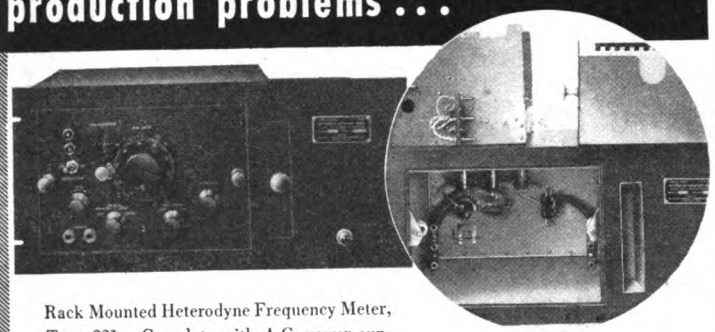

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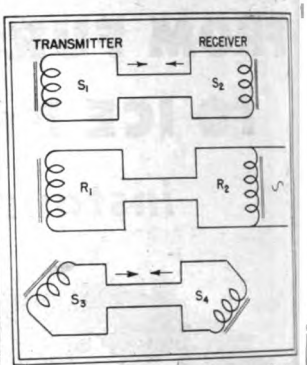

FIG. 7—Turning R_1 will cause R_2 to rotate

in Fig. 7, stator S_2 will repel rotor R_2 and stator S_4 will attract rotor R_2 since the current from S_1 has reversed the original poles of S_2.

In Fig. 8, three stators are shown displaced 120 degrees on each motor. In actual construction, interwound multiple poles are used. The same degree of coupling exists between R_1-S_1 and R_2-S_2, R_1-S_3 and R_2-S_5, R_1-S_5 and R_2-S_4. Since the voltages across the respectively connected stators are equal and opposite, the system is in neutral position.

Multiple Stators

In Fig. 9, transmitter rotor R_1 has been displaced 45 degrees by external means. Coupling between R_2-S_2 is now tighter than R_1-S_1, thus current will flow from S_1 to S_2 because the voltage is higher across S_2. This current flow is due to induced current R_2 to S_2 and S_1 will repel R_2.

Coupling between R_2-S_6 is greater than R_1-S_5, thus the voltage across S_6 is higher than across S_5, current

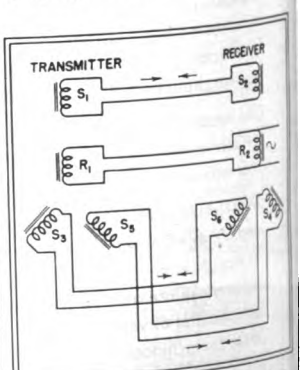

FIG. 8—Neutral position with three stators in each motor

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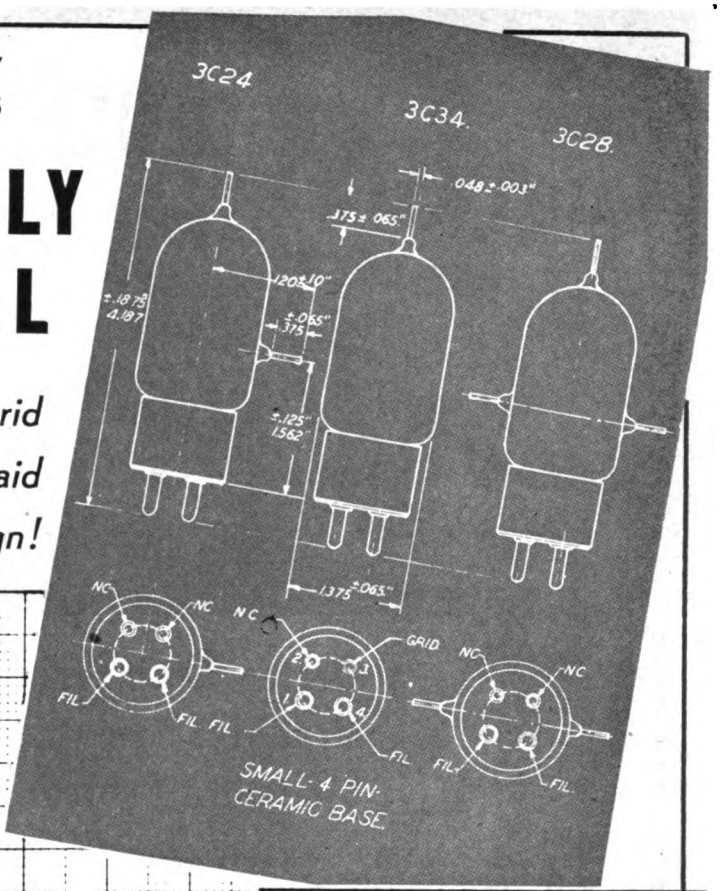
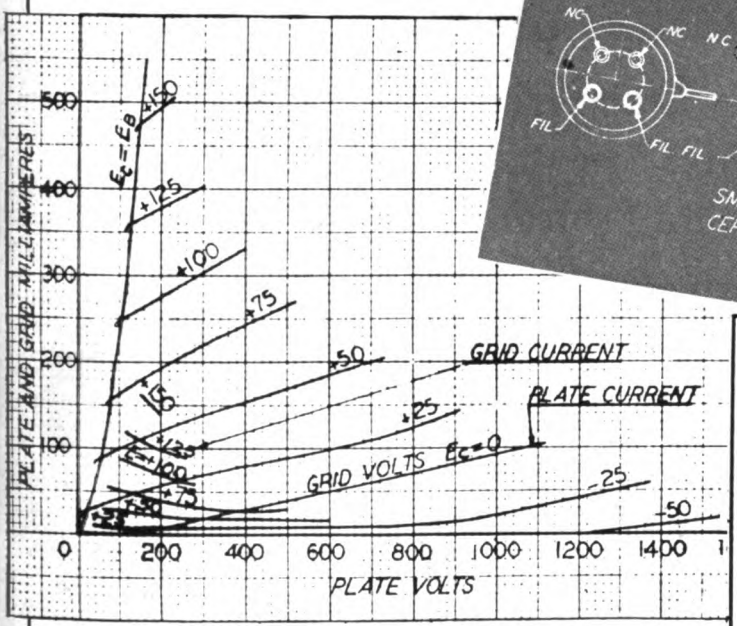
TRANSMITTING TRIODES

ELECTRICALLY IDENTICAL

... but with different grid terminal locations to aid in your equipment design!





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HIGH FREQUENCY TRANSMITTING TRIODES

Filament	Thoriated Tungsten
Voltage	6.3 ac or dc volts
Current	3.0 amps
Amplification factor	25

Direct Interelectrode Capacitances:

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Grid-Plate	1.6	1.7	1.8	mmfds
Grid-Filament	2.0	2.5	2.1	mmfds
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	3C24	3C34	3C28	
Full power input	60	60	100	mcs
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In Walker-Turner Remote Control Shafting oxidation is minimized by a special process involving a copper sulphate bath—thus insuring long, trouble-free service. Whether your products require flexible shafting for remote control, power transmission, or both, you can always count on Walker-Turner Flexible Shafting for the high quality that produces high performance. Write for our latest catalog.

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FLEXIBLE SHAFTING
FOR REMOTE CONTROL AND POWER TRANSMISSION

will flow from S_6 to S_3 and, since this current flow is due to induced current (R_2 to S_6), stator S_6 will also repel rotor R_2. Coupling between rotor R_1 and stator S_3 is tighter than R_2-S_4, hence the voltage across S_3 is higher than across S_4. Current will therefore flow from S_3 to

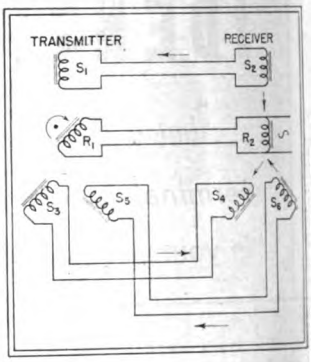

FIG. 9—Stators S_2 and S_6 repel rotor R_2; stator S_4 attracts R_2

S_4. Since the currents are out of phase, the largest will predominate and current from S_3 will reverse the poles on S_4; therefore coil S_4 will attract rotor R_2. Rotor R_2 will rotate 45 degrees and the voltages across the respectively connected stator coils will again be equalized; the induced currents will cancel returning the system to a neutral position with equal voltages across connected stator coils.

In Fig. 10, the transmitter and

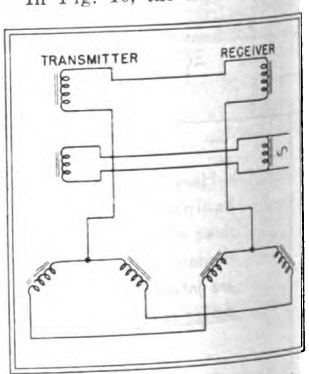

FIG. 10—Wye connection of coils equivalent to Fig 9

receiver coils are shown in wye connection which is electrically equivalent to Fig. 9. The reader should have no trouble solving the rotation of the receiver rotor through 360 degrees of rotation.

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New-Sensational, RADIART MIDGET VIBRATOR has Many Applications!

ACTUAL SIZE

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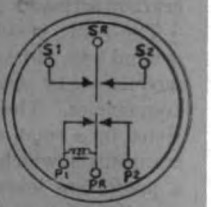
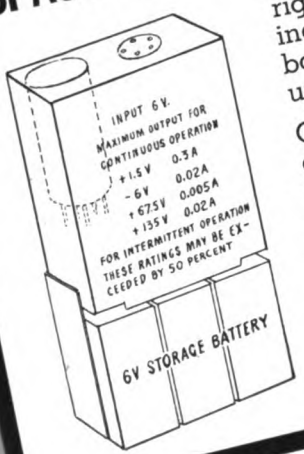


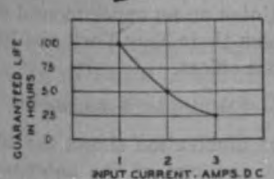
P- PRIMARY
S- SECONDARY
R- REED



Overall dimensions of unit were rigidly fixed at 6½" x 3½" x 1¾"—including a rechargeable storage battery as well as the power supply unit.

Obviously a standard size vibrator could not be used—so RADIART developed the VR-2 Midget Vibrator for the job.

Check the vibrator specifications given below as well as operating data on the illustration of the power supply for details.



SPECIFICATIONS

Vibrator Frequency . 185 CPS ±10%
Input Voltage, Nominal . . . . . 6.0 V.
Input Voltage Range . . 4.5 to 7.5 V.
Output Voltage . . 200 V. D.C. Max.
Potential Difference
Between P_R & S_R . . . . 25 V. Max.

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TUBES AT WORK

Army Target Plane Controlled by Radio Transmitter..... 300
Microwave Radio Relay to Replace Telegraph Lines..... 300
Tube for SCR 270 Radar..... 308
Drafting Aids to Relay Profiling..... 316
Measurement Applications of the Dynatron..... 320

Army Target Plane Controlled by Radio Transmitter

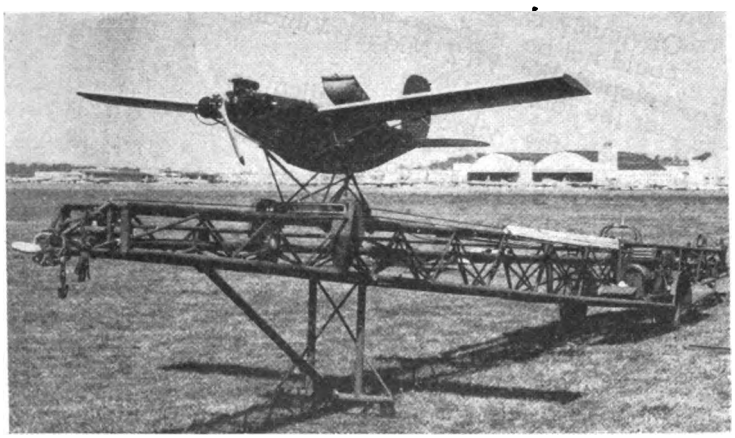
RADIO-CONTROLLED pilotless planes have been used by the Army as targets for aerial gunnery practice by B-29 gunners and also for anti-aircraft practice by ground forces.

The plane is controlled from the ground by a uhf transmitter that is modulated by five different audio frequencies. These tones are selected by a small control box at the transmitter which is equipped with a projecting lever to simulate the joy stick of a plane. Two of the a-f signals provide rudder control and two provide elevator control. The fifth frequency centers the rudder and releases a parachute when desired by the control operator. Only one frequency is used at a time and when none is being transmitted the parachute release frequency is automatically switched on.

Servo System

In the plane, a radio receiver and a selector circuit translate the signals and actuate a servo unit to provide mechanical action to control the elevators and rudder. The elevator and rudder servo controls remain in effect after the engine stops and the parachute is released, providing the receiver has not been damaged, so that dead-stick landings may be made in the event the parachute attachments are shot away.

Two models of the remotely controlled planes are standard equipment for the Army Air Forces. One model, the OQ-3, is a high-wing monoplane, 9 feet long, having a wing span of 12 feet 3 inches. The plane is constructed of welded steel tubing covered with airplane cloth and weighs 100 pounds. It flies at 103 miles an hour and is powered by an 8-horsepower 2-cylinder gasoline engine.



Radio-controlled target airplane model OQ-14 on its launching catapult. It provides realism for student gunners by simulating flight attitudes, dives and evasive action in response to modulated signals from a transmitter on the ground

A later model, the OQ-14, is powered by a 22-horsepower engine, flies 140 miles per hour and has a wing span of 11 feet, 6 inches. The planes are launched from a catapult driven by compressed spring coils or rubber cords. They fly at altitudes up to 3000 feet normally.

Another use for the plane was found recently, that of a training aid for students of radar in tracking flying objects in the air for gunnery practice. In addition, the Navy is using the target airplane in its training for automatic weapons target practice.

The first models developed had a telephone dial on the control unit, used a 3-hp engine with counter-rotating props to counteract torque, and had a tricycle landing gear. These features were eliminated in the experimental stages.

The target planes are the result of eight years of research work by Lt. Col. C. O. French, Jr. and his staff at Air Technical Service Command Headquarters, Wright Field, Dayton, Ohio. They are manufactured by Radioplane Co., Van Nuys, Calif. and Globe Corporation, Joliet, Ill.

Microwave Radio Relay to Replace Telegraph Lines

MICROWAVE radio relay systems with towers about 30 miles apart between the major cities of the United States will be installed during the next seven years by Western Union Telegraph Company. No lines will be removed from the present 2,300,000-mile telegraph network until the radio system along the route has proved satisfactory, government approval is obtained and existing contracts permit.

A test circuit was installed between New York and Camden, N. J. early this year by engineers of Radio Corporation of America who developed the system. Since March, this circuit has been used by Western Union on an experimental basis between their New York and Philadelphia offices.

Multiple Antennas

The illustration shows the 100-ft tower and two of the antennas at one of two intermediate relay stations used between New York and Philadelphia. These are located near Bordentown, N. J. and at 10-Mile Run near New Brunswick, N. J. The stations are unattended and operate automatically.

On top of each tower is an 8-ft

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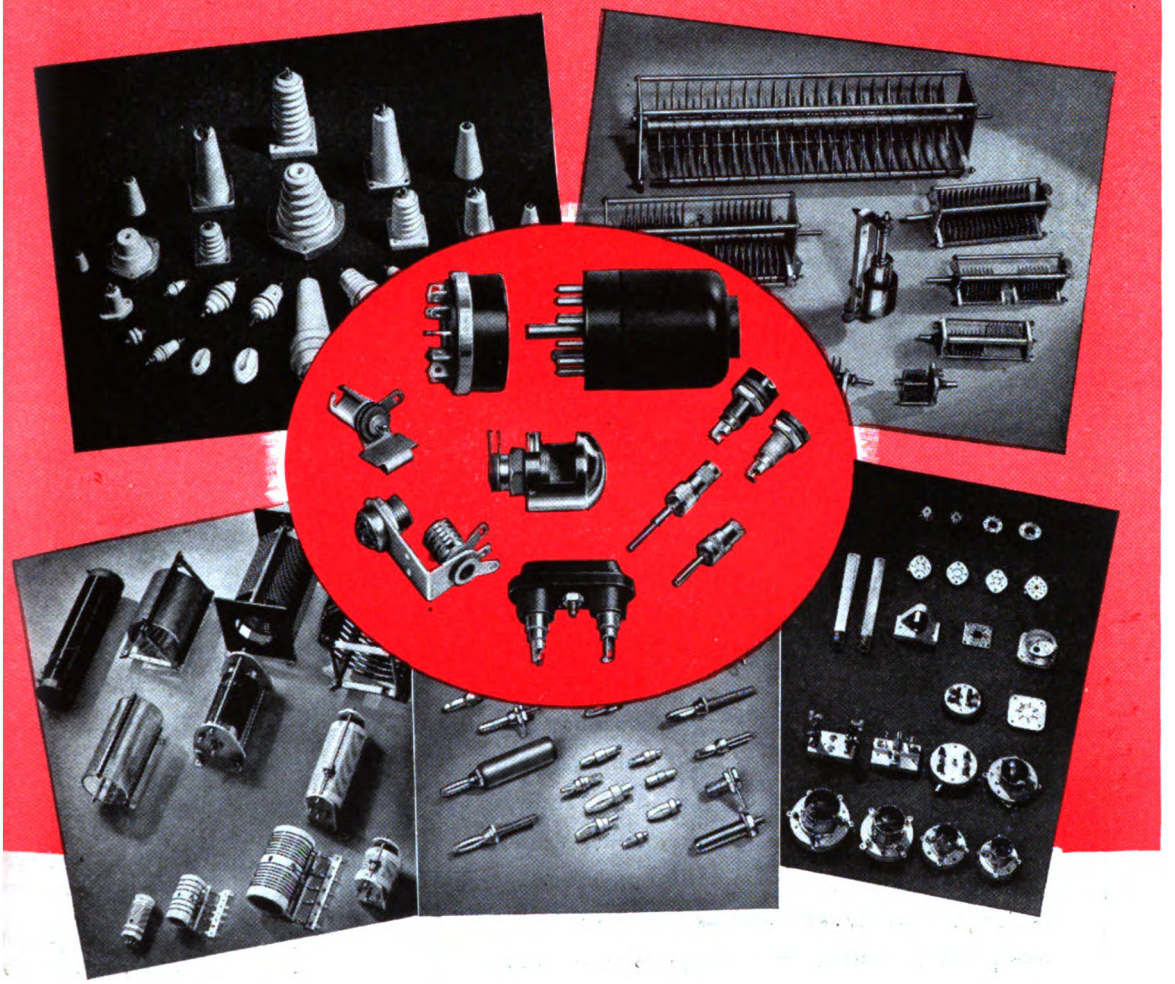

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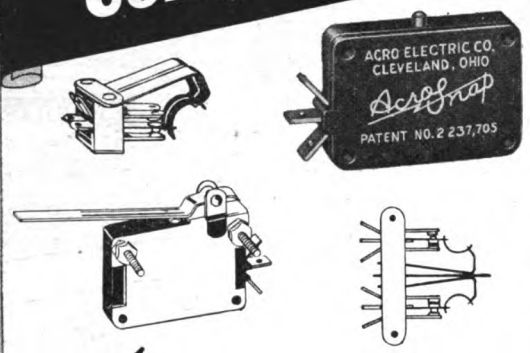

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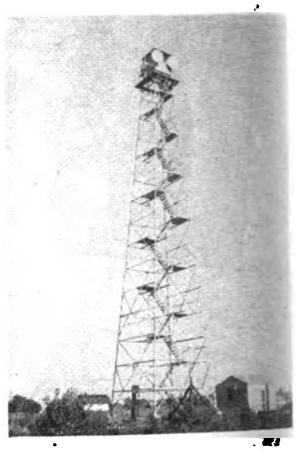
THE ACRO ELECTRIC COMPANY

1316 SUPERIOR AVENUE • CLEVELAND 14, OHIO

square enclosed cabin. Outside the cabin four antennas are mounted in parabolic reflectors. One antenna on the east side of the tower feeds the East-to-West receiver; the other is supplied by the West-to-East transmitter. Two other antennas on the West side of the tower are



Four parabolic antennas and a cabin enclosing the transmitting and receiving equipment are mounted atop a 100-foot tower for use in the Western Union radio relay system

used on the West-to-East receiver and the East-to-West transmitter. The transmitters, receivers, demodulators and modulators are housed in the cabin.

The transmitters in the present system put out about one-tenth of a watt. However, the antennas have a power gain of 900 (so that the equivalent non-directive power is 81 kilowatts). This provides a transmitter-antenna to receiver-antenna gain of 810,000. Operation is being conducted on a frequency near 4,000 megacycles with a useful bandwidth of 150 kilocycles. It has been estimated that this is sufficient for 270 multiplex or 1080 single telegraph circuits. It could probably handle at least 25 ordinary telephone circuits, or if used for high-quality f-m broadcast service possibly eight channels. The present bandwidth is insufficient for television, but new equipment of higher power may be available soon to provide the necessary 6-mc television bandwidth.

As now used, the system provides

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square enclosed on a
cabin four antenna
parabolic reflectors, o
on the east side of the
the East-to-West receiv
is supplied by the
transmitter. Two
on the West side of the

Four parabolic antennas
enclosing the transmitting
ing equipment are mount
100-foot tower for use in
Union radio relay

used on the West-to-East
and the East-to-West
The transmitters, rec
modulators and mod
housed in the cabin.

The transmitters in
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handle at least 5
phone circuits, or if
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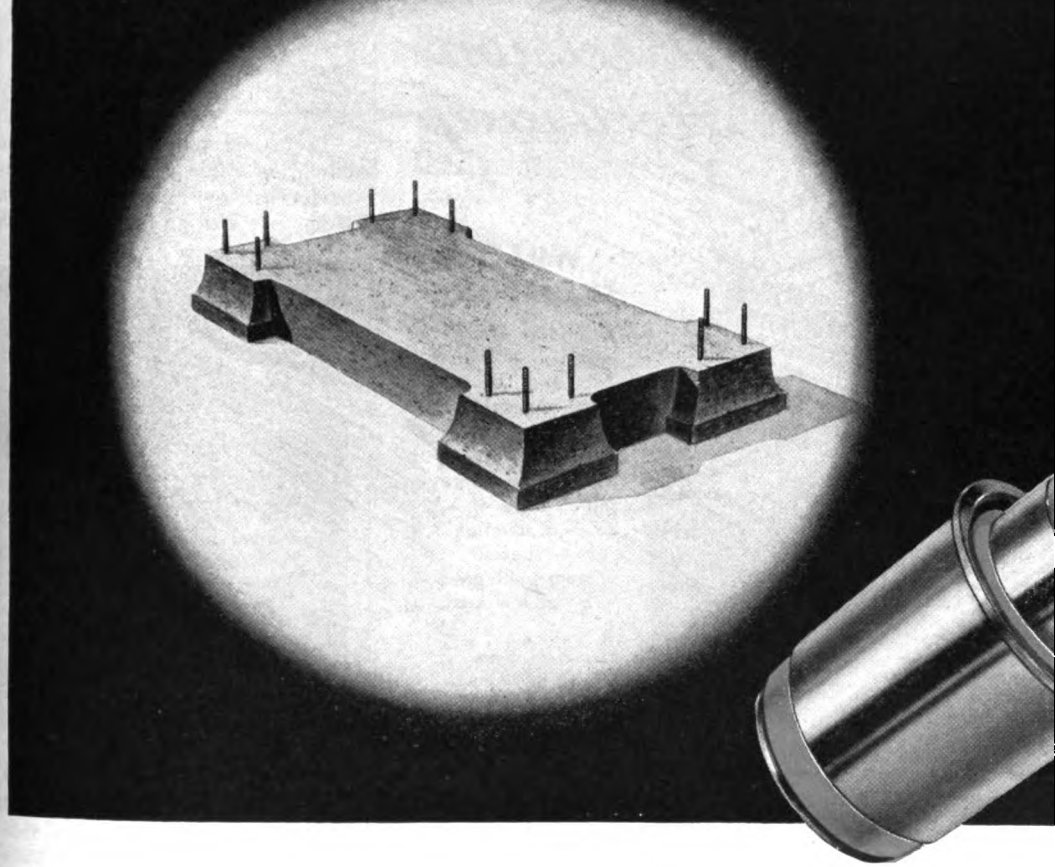
As now used, the

December 194

If users need bases like this..



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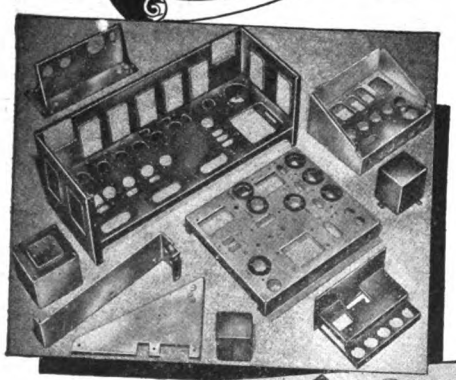

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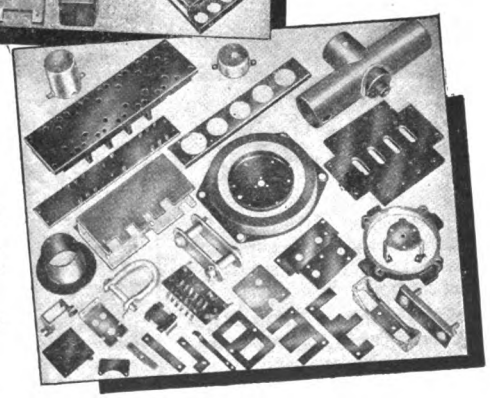

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a total of 40 telegraph channels, one two-way phone channel, and one two-way facsimile channel. Frequency modulation is used and each telegraph signal goes out as two frequencies; one is a marking impulse and the other a spacing pulse to the receiving printer. A 70 cycle swing of signals spaced 300 cycles apart is involved.

Progress

In its six months operation to date, the radio relay circuit has performed so well that Western Union has filed an application with

One of the 4,000-mc antennas is examined by H. P. Corwith, assistant chief engineer of Western Union

the FCC for permission to install equipment of a similar type from New York to Pittsburgh, Pittsburgh to Washington, Washington to New York, and New York to Philadelphia. Its establishment in time will permit the removal of about 2500 miles of pole lines with some 54,000 miles of wires and 180 miles of aerial and underground cable.

Besides terminal equipment in the four cities, 21 intermediate relay stations in towers on mountains ranging from 14 to 55 miles apart would be constructed. The sites for these have been acquired.

• • •

Tube for SCR 270 Radar

COOPERATIVE ACTIVITY between the Army Signal Corps and Westinghouse Electric Corp. produced the special radar tube shown in the

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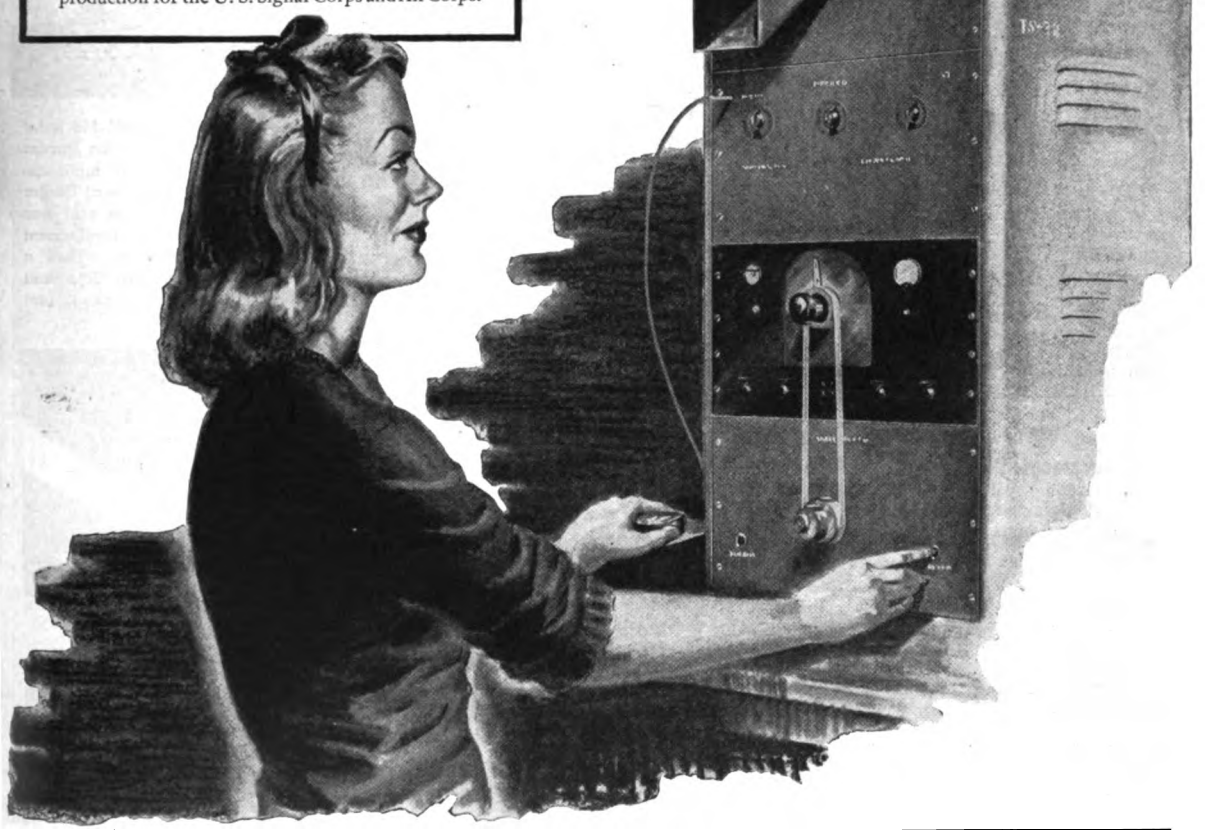

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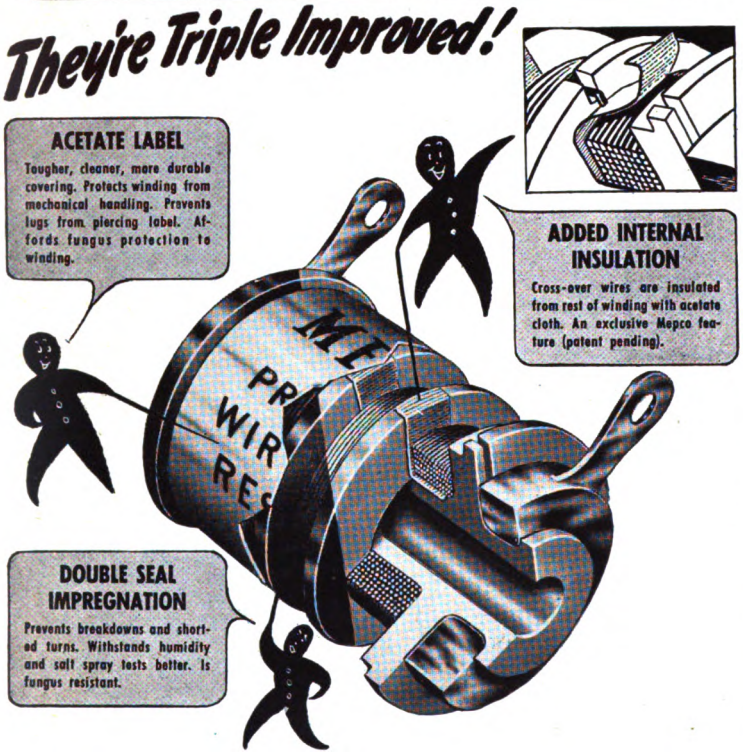

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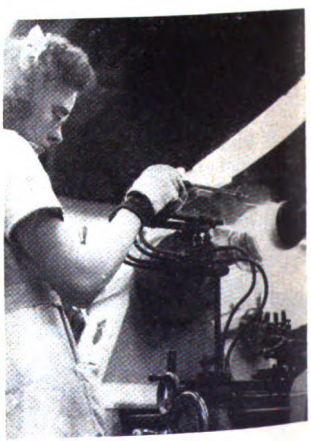
accompanying illustrations. It was used in long-range detection sets, one of which revealed the impending attack on Pearl Harbor and another guarded the Panama Canal a year before.

Of revolutionary design, the tube produced ten times the power of uhf tubes previously built and involved manufacturing problems at first regarded as insurmountable. Besides geometrical and physical characteristics departing radically from known techniques, the tube called for extremely difficult copper-to-glass feather-edge seals and momentary peak currents which de-

Finished example of type WL 530 radar tube. This unit served in the famous SCR 270 which detected the approaching Japanese attackers of Pearl Harbor Production of copper-to-glass seal was one of the difficult parts in development of the WL 530 radar tube. Here a worker in the Fairmont, W. Va., plant of Westinghouse molds the anode seal



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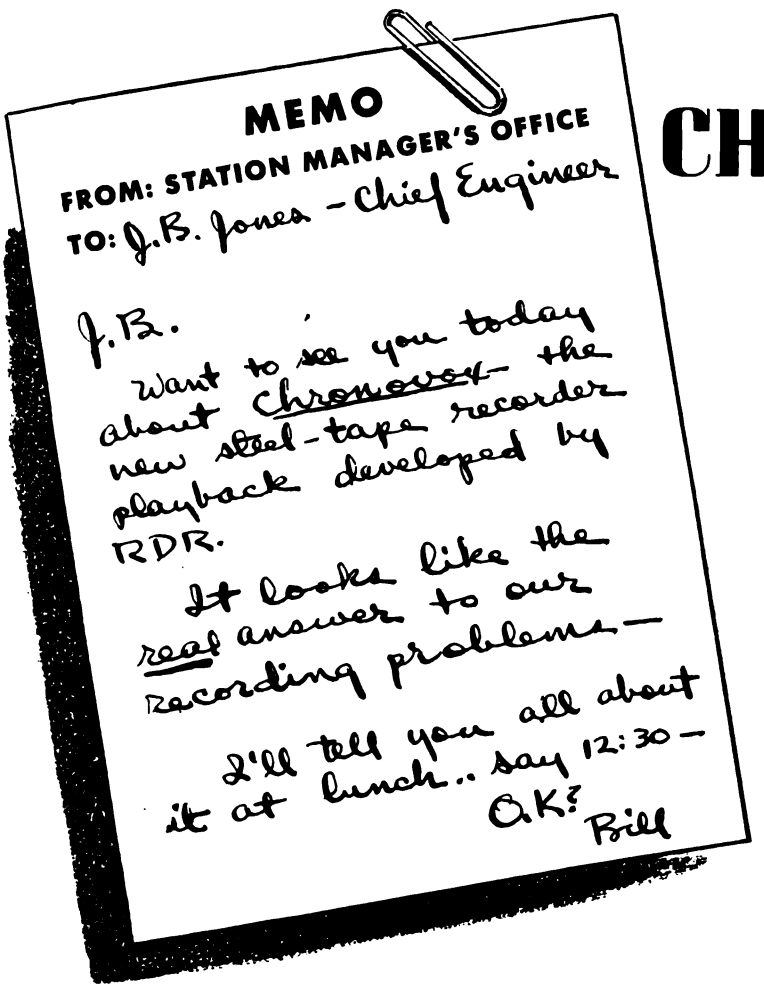
Making Steel Talk



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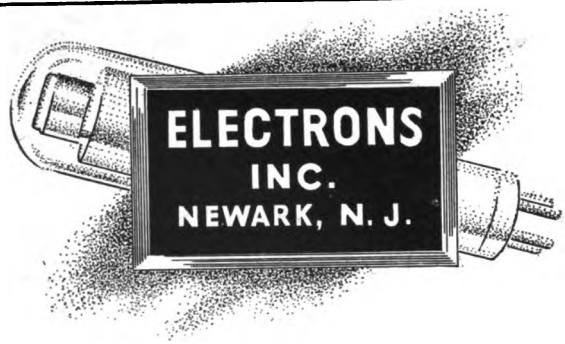

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EL Rectifier TUBES

manded a specially-treated tungsten filament able to withstand five times the voltages believed possible.

The project was taken over by Westinghouse electronic engineer Ilia E. Mouromtseff, who had, back in 1933, done line-of-sight transmission work which led to the detection of automobiles passing by on the highway outside the East Pittsburgh plant of the company. Tubes of similar construction are expected to contribute to the future advancement of f-m and television equipment.

• • •

Drafting Aids to Relay Profiling

By F. J. BINGLEY

Chief Television Engineer
Philco Radio & Television Corp.
Philadelphia, Pa.

PROFILING of the terrain along the line-of-sight television path recently built between Washington and Philadelphia (See ELECTRONICS, Oct. 1945) was necessary because it was desired to obtain at least 100 feet of ground clearance at all points on the transmission path. This clearance was to be provided by the use of two 100-foot antenna towers, one for receiving and the other for transmitting television signals at each relay site selected.

After a study of U. S. Coast and Geodetic Survey maps, four tentative hilltop sites for relay stations were chosen. Then a device, which has been named the Contourograph, was used to prepare profiles of the ground contour between each pair of sites to learn the exact ground clearance along each section of the proposed network.

The instrument is shown in the accompanying illustration. It consists of a double-ended T-square, actually an H-square, with an added cursor. The two vertical legs of the H are used to mark on the map the two end points of a path which is to be profiled, with one leg movable to permit adjustments in the length of the contour section.

Distance and Elevation

The slider which is moved along the horizontal leg of the H-square, is graduated in feet of altitude to an arbitrary scale. Thus as it is

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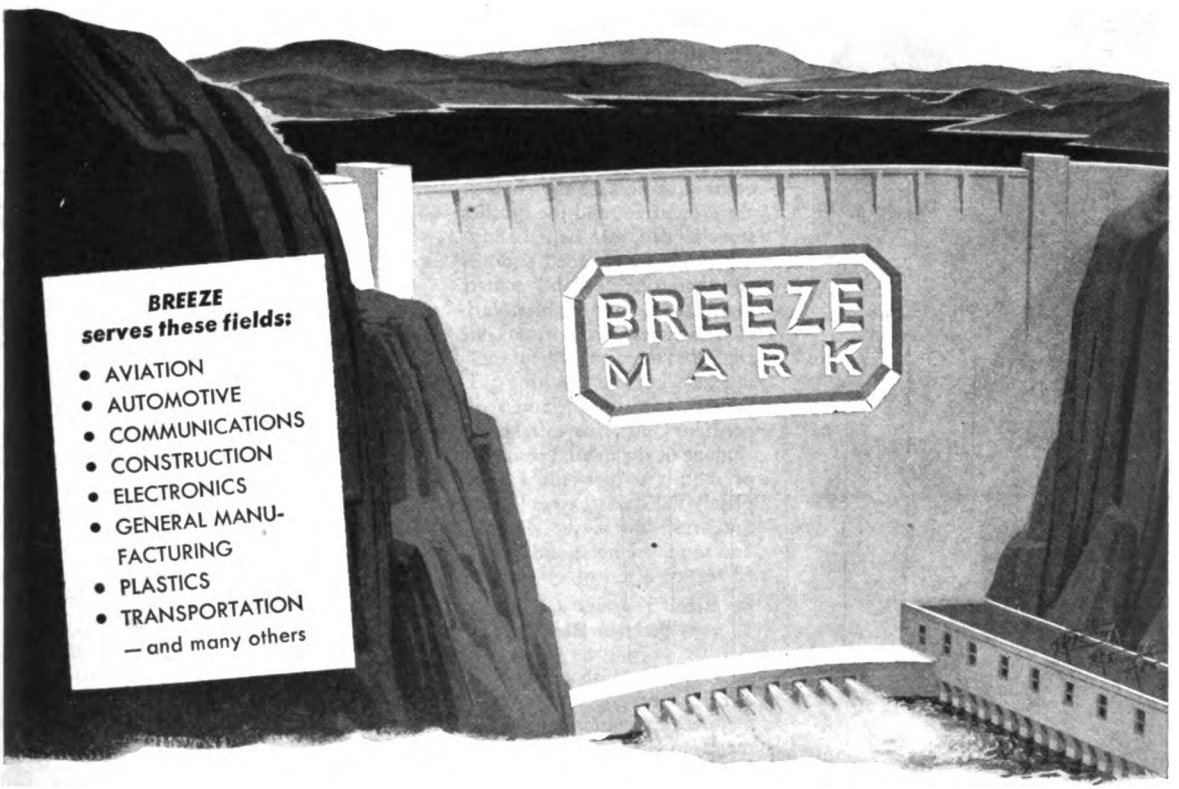

THROUGH diversified manufacturing operations covering a period of nearly two decades, Breeze has built up a vast reservoir of skills and facilities which now may be tapped by manufacturers faced with reconversion problems. Already Breeze has helped two producers of consumer goods to recapture pre-war markets . . . and turn a handsome profit while their competitors were still trying to figure out what to do about re-tooling for peacetime production. And in the same manner that it has helped others, Breeze may be able to help you.

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. . . To produce in vast quantities for war such precision items as Breeze Radio Ignition Shielding, Flexible Conduit and Fittings for aircraft, automotive, tank and marine engines; Aircraft Tab Control Mechanisms, Electrical Connectors, Flexible Shafting and Casing, light-weight Armor Plate and countless other specialties.

Today, properly applied, the Breeze processes, equipment and techniques which made so many important contributions to Victory may enable you to get goods back on the market months ahead of your competition. The wide variety of services Breeze offers are described graphically in "Planning for Reconversion". Send for your free copy of this interesting booklet today. It may suggest a direct adaptability of Breeze skills and facilities to your commercial production needs.

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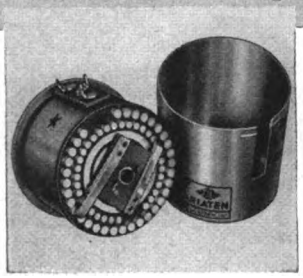

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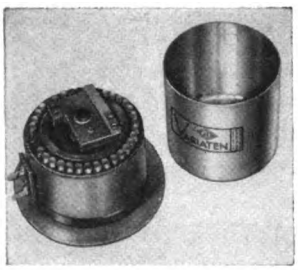

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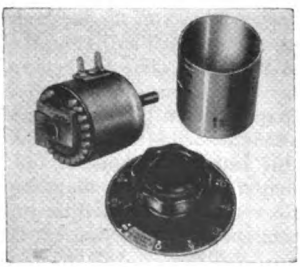

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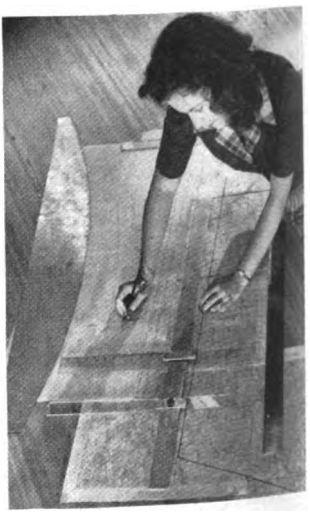
moved along the route between relay sites, the altitudes are read from the contour line intersections on the map and transferred directly as points to a sheet of paper placed above the map and between the ends of the H-square as shown. A series of points are plotted on this paper, and then connected to provide a profile of the ground contour between proposed relaying stations. Distances between transmitting sites are represented horizontally on this profile, while the ground elevation is shown by vertical distance from the base line.

Besides time saving, a second advantage of the Contourograph is that it greatly reduces the chances for error in locating profile points.

Additional Template

Since the curvature of the earth's surface is another factor important in profiling for line-of-sight television transmission it has been necessary to use an auxiliary piece of equipment. This is a curved template, cut on a scale corresponding to the altitude scale of the Contourograph cursor, with its radius of curvature representing the inverse of the earth's curvature. This template is placed so its curved edge passes through the



Profile charts for line-of-sight relay routes are plotted with the aid of this modified T-square. Template at left represents a straight line as affected by curvature of the earth

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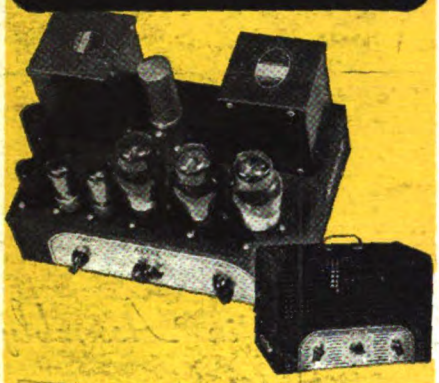

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end points of the profile, and a curve is traced on the paper. If desired, an allowance can be made in this template for the refraction of television waves by the earth's atmosphere—usually accomplished by using as a base figure 4/3 the actual radius of the earth. However, by using the actual radius for this system, Philco was conservative in the matter of clearance on the profile drawing.

To make an instrument capable of simultaneously providing altitudes for profile points and curvature corresponding to the earth's, it is merely necessary to modify the Contourograph by making the upper edge of the horizontal leg curved to represent the earth's curvature. The cursor travels along this curved surface. Then both operations are combined into one simple plotting process.

• • •

Measurement Applications of the Dynatron

By Wayne M. Ross
Wallace, Idaho

THE DYNATRON oscillator is a very interesting and useful circuit that seems to have been overlooked by many research and service engineers. As is commonly known, the operation of this type of oscillator results from secondary emission in certain types of tetrodes or screen grid tubes having no suppressor grid, notably the old 24A. When the plate voltage is less than that of the screen, a large amount of secondary-emission current flows from the plate to the screen grid. This causes the plate current to increase as the plate voltage is decreased and to decrease with an increase, in plate voltage, thus, in effect producing a negative resistance. If a resonant circuit is placed across this resistance and the resistance made sufficiently negative to overcome the losses of the circuit, it will oscillate with no other form of reaction or feed back.

As, in a resonant circuit, the greater the resistive losses the lower is the dynamic resistance, so the more damped circuit will require a lower negative resistance to produce oscillations. This value of negative resistance varies consid-

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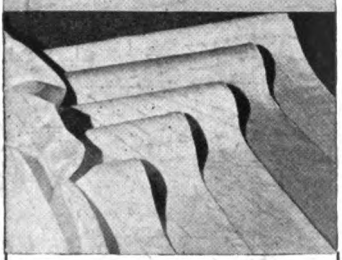
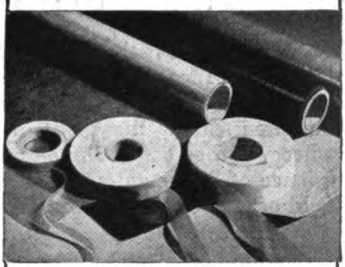


Untreated, continuous filament, Fiberglas Cloth is made in thicknesses from .0015" to .015" — staple fiber cloth from .012" to .023".



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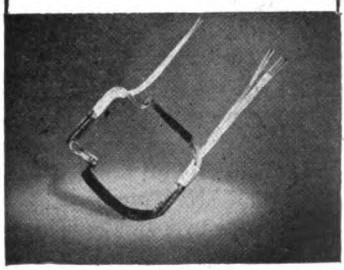

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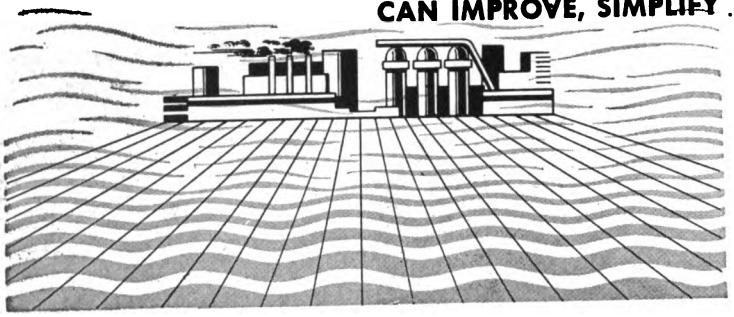

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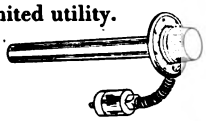

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erably with different tubes. Some of the early type 24A's will provide a resistance of approximately 5000 ohms. Almost any of them will provide 10,000 ohms which is sufficient for most work. The negative resistance is also directly controllable by means of the control-grid bias, being lowest in value when the bias is zero.

A dynatron circuit, arranged for convenience in doing experimental work, is shown in Fig. 1. In addition to the components shown, useful accessories are: a calibrated

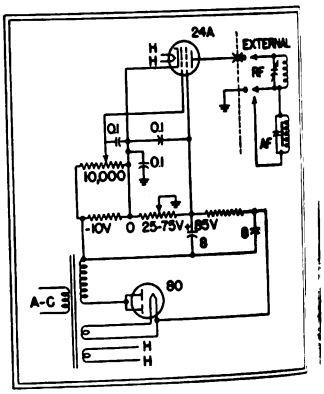

FIG. 1—Once popular in test oscillators, the dynatron circuit operates most efficiently with the early 22 and 24A-type tubes. The circuit above provides convenience in making many measurements

wavemeter, preferably a non-absorption type, a variety of coils and a capacitor calibrated over the desired frequency ranges, and a large slide-type dial. The 24A tube should be mounted horizontally so that the lead between the plate and external connection is short. The basis for dynatron measurement applications are the dynamic resistance of a tuned circuit and the resonant frequency or change in frequency.

Grid Voltage as Indicator

The dynamic resistance is determined by the most negative control-grid voltage that will still maintain oscillation. This voltage may be controlled by a wire-wound potentiometer, the scale of which may be calibrated to read the negative resistance, or a voltmeter may be used to measure the bias voltage

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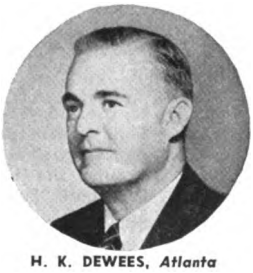

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and a chart made to read the negative resistance. The value of negative resistance may be computed from the E_pI_p curve at various bias voltages, or, if approximations are sufficient, standard coils whose dynamic resistance is known may be used. The negative resistance is equal to the dynamic resistance of the circuit when the bias control is set just at the point of oscillation.

The frequency or change of frequency is determined by the loosely coupled wavemeter or a nearby receiver. The wavemeter is also necessary to determine the point at which oscillations begin.

A parallel-resonant circuit may be tested directly by connecting it to the terminals shown in Fig. 1. The dynamic resistance will be indicated by the potentiometer setting at which oscillation begins and the frequency of the circuit will be shown by the wavemeter.

Capacitance and Inductance

Perhaps the more useful is the substitution test. In this case, a tuned circuit of known values is caused to oscillate. The component to be tested is then clipped across this circuit. Oscillation will probably cease but may be reestablished by decreasing the control-grid bias. This decrease in bias will correspond to the effective resistance of the component under test. If the component contains reactance, the frequency will be altered. The tuning capacitor may be adjusted to restore the original frequency. This adjustment may be calibrated to read capacitance in one direction and inductance in the other. This will not indicate true inductance or capacitance but the effective value at that frequency.

Signal Source

Additional uses to which a dynatron may be put include application as an a-f, r-f, or modulated r-f oscillator. When operated with sufficient control-grid bias so that oscillation is only just maintained, the frequency stability is excellent. Since the amplitude of oscillation may be controlled by the control-grid bias, this factor may be useful for automatic amplitude control. If a modulated oscillator is desired,

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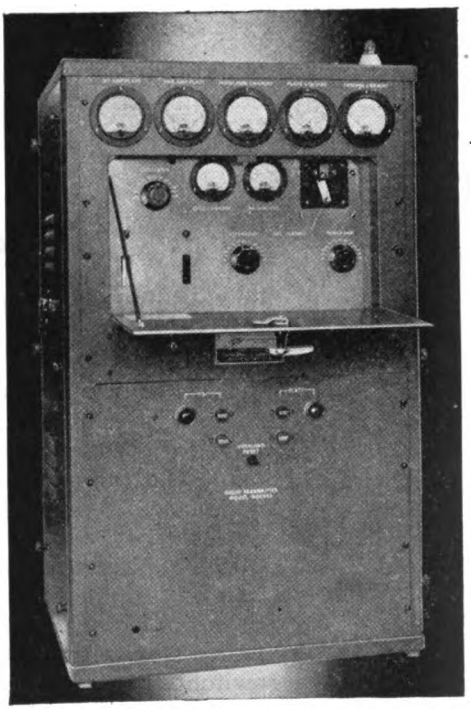

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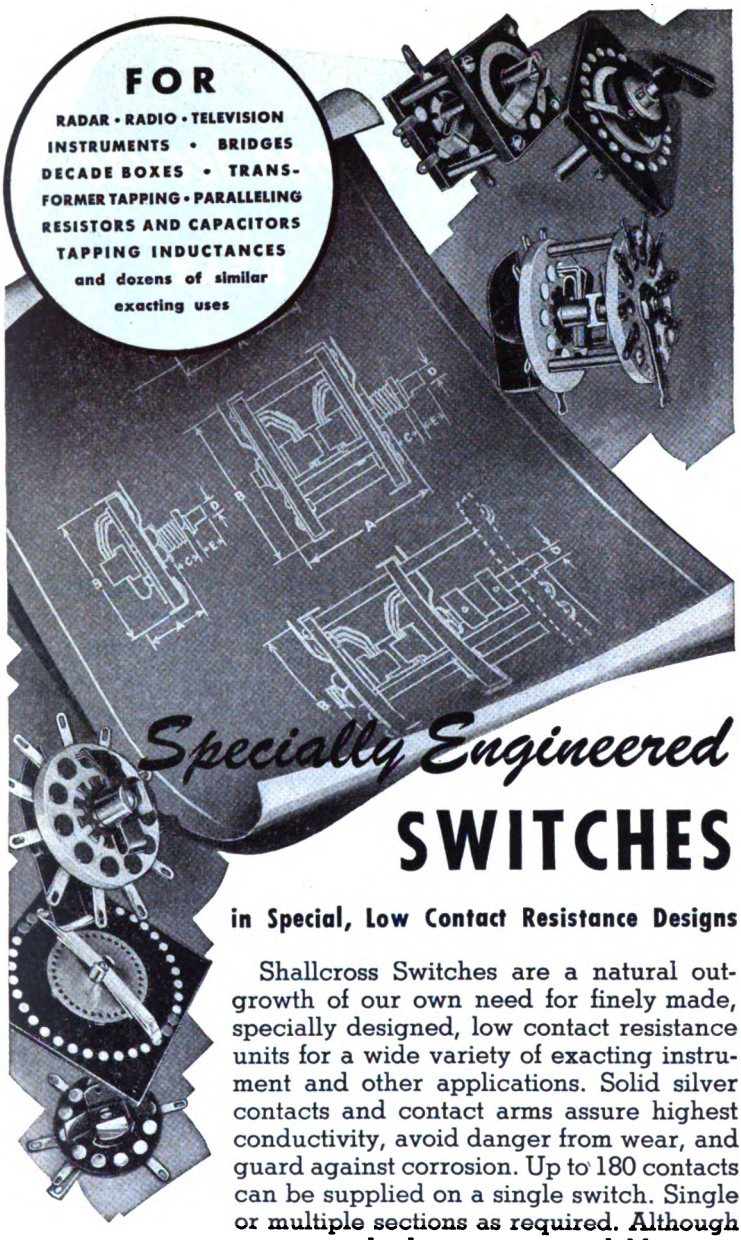

the r-f and a-f tuned circuits are merely connected in series as shown in Fig. 1.

Measuring effective inductance of small r-f coils can be done if the wavemeter is set to a predetermined setting, say 1000 kc the coil clipped on and the dynatron turned to the wavemeter setting. The dial can be calibrated to indicate the inductance directly in microhenries. This can be done using standard inductances with interpolation between available values.

Using a good quality, 365-$\mu\mu$f capacitor, the 1000-kc setting would provide a scale of approximately 75 to 200 microhenries. A frequency of 1500 kc would provide a scale of 25 to 75 microhenries; 500 kc, the scale of 200 to 1000; and 250 kc, the scale of 1000 to 500 microhenries. This may be carried to as low a frequency as desired, provided the coils are of sufficient Q.

Measurement of inductance in the a-f range may be obtained by providing the wavemeter with a resonant audio circuit and a small capacitive coupling to the grid of the wavemeter. A capacitor decade box is also useful. Using this as the variable capacitor, the coil is tuned to the wavemeter frequency. The amount of capacitance in the circuit may be charted to indicate inductance.

Greater Accuracy

A method for acquiring a more accurate reading of inductances may be worked out by computing changes of capacitance against changes in frequency. These measurements may be carried well into the high-frequency bands but here the value of the tube as a dynatron becomes critical.

Mica and paper capacitors may be measured in conjunction with a known inductance. The frequency of oscillation, when the capacitor is inserted, indicates the capacitance when calculated against the known inductance. Leakage or resistive losses will be indicated by the lower Q as compared to that when a good capacitor is used.

Resistance of Chokes

In testing r-f chokes, it is useful to provide a parallel resonant cir-

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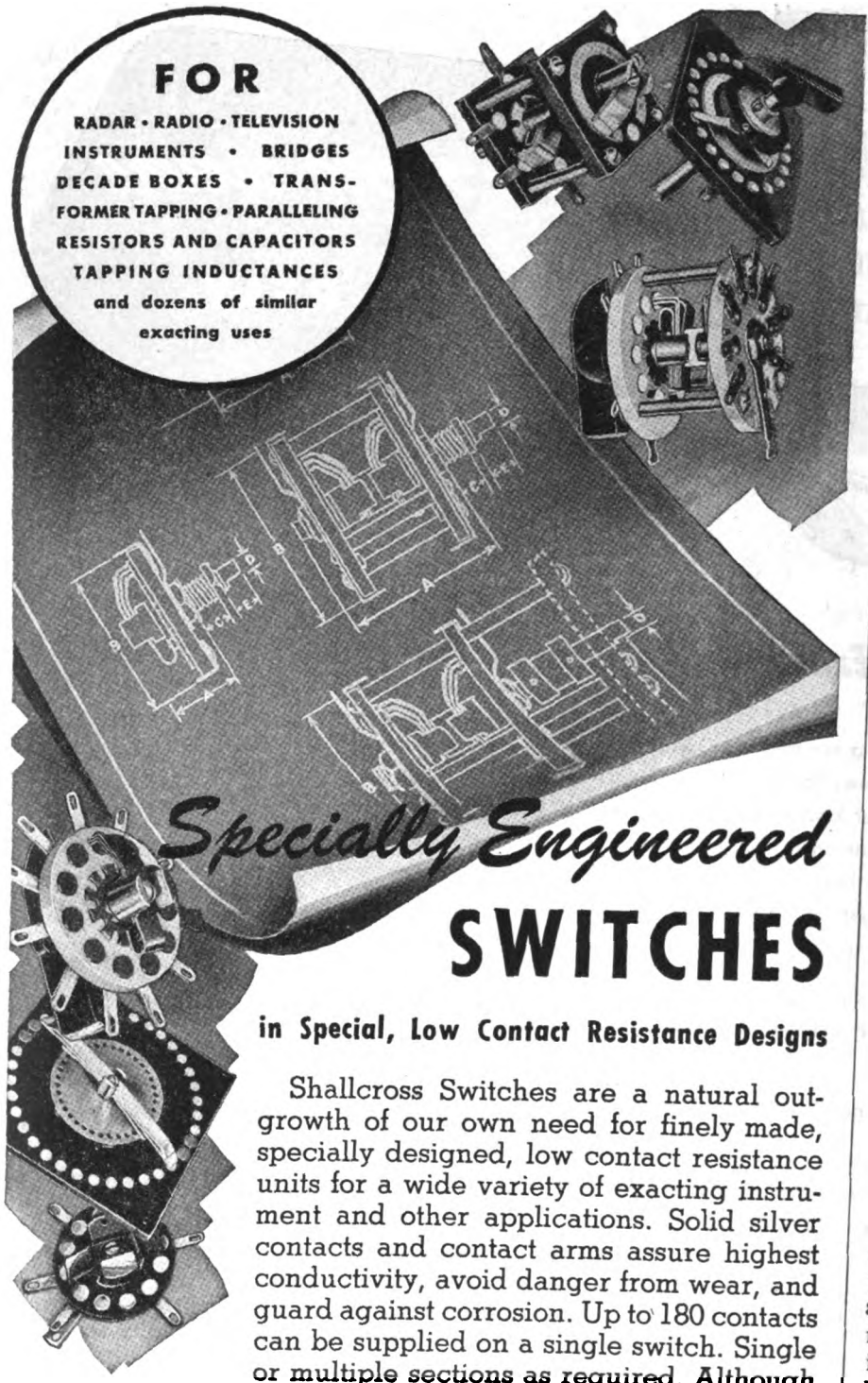

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cuit. A frequency is chosen, say 500 kc, and the coil is made to tune to this frequency with approximately ½ of the plate area of the tuning capacitor meshed. This point on the dial should be marked zero. If the choke is then clipped across the tuned circuit, the frequency will be altered. The capacitor is then increased until 500 kc is again obtained. This point on the dial can be calibrated to show the value of the added inductance of the choke.

When the choke is shunted across the circuit it will probably stop oscillating. It is necessary to lower the control-grid bias to reestablish oscillation. This will indicate a lower dynamic resistance the value of which will be that of the two coils in parallel.

When the dynamic resistance of the coil alone is known, that of the choke may be computed. Or, different values of resistance may be shunted across the tuned circuit in place of the chokes. The value of resistance that requires the same setting of the control-grid potentiometer to produce oscillation will be equal to the effective resistance of the choke.

The instrument may also be used for matching coils using a fixed, standard capacitor and for comparing properties of insulating materials.

Operating Conditions

With the circuit shown, the plate voltage may be between 25 and 75 volts. Maximum efficiency is obtained by increasing the negative grid bias until oscillation just ceases, then oscillation is reestablished by varying the plate voltage. This operation should be repeated until an optimum condition is found.

Another method is to adjust the bias to a slightly negative value, then shunt the oscillating circuit with decreasing values of resistance until oscillations cease; then re-established, as before by varying the plate voltage. This operation should also be repeated to optimum conditions. The plate voltage should then be fixed and not varied after the control-grid potentiometer is calibrated.

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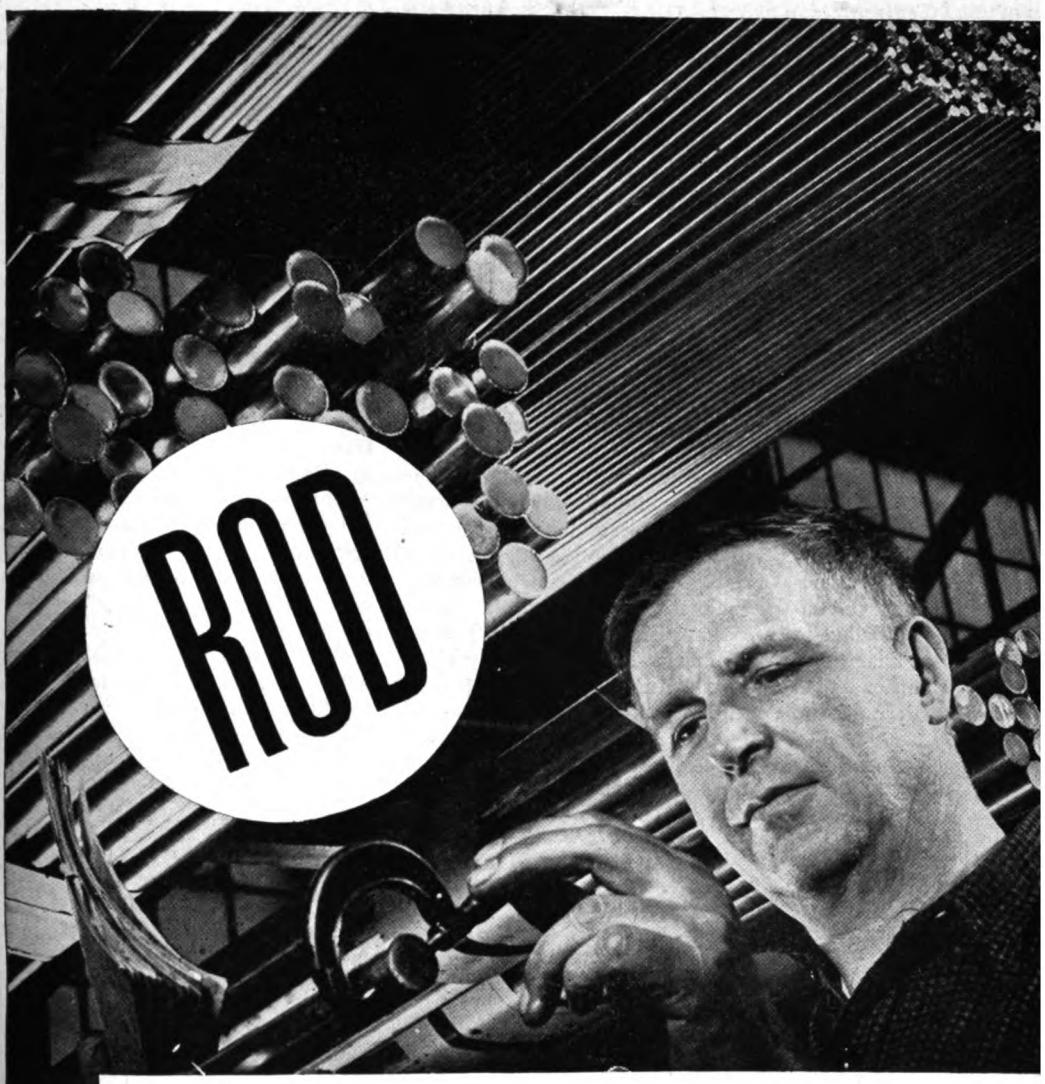

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Sensitive Television Camera Tube

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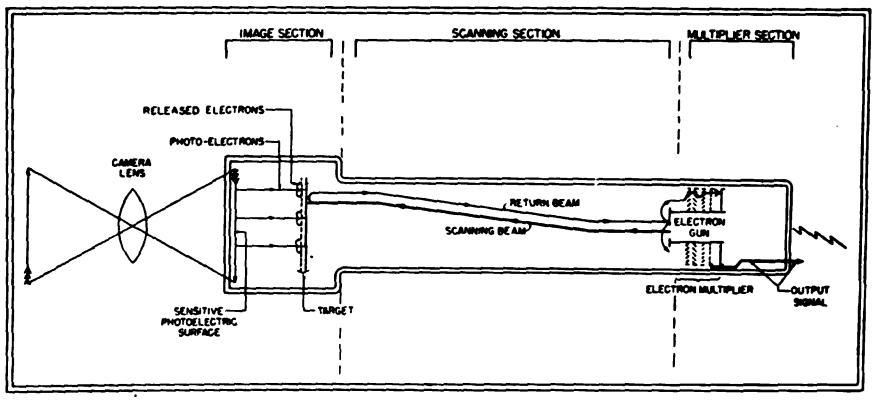

Image orthicon separates functions of photoelectric image conversion and scanning, and incorporates an amplifier

Operating Principle

As can be seen from the accompanying diagram, the image orthicon separates the functions of converting a light image into an electrical image, and of scanning the image. Because of this division of functions, each element can be designed for optimum performance thus giving maximum sensitivity.

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The scanning target is a semiconductor. The focused, derivative electrons that reach it set up charges. Because electrons are constantly reaching the scanning target, 100-percent image storage is obtained in this fundamentally orthicon-type tube. The target is scanned by a magnetically controlled beam. The target itself is at the same potential as the beam cathode, thus where the target has become charged from the image electrons, it reflects the electrons of the scanning beam in proportion to the image intensity, flected electrons are i pick-up, annular-ring rounding the cathod ductivity and thickness conductive scanning t chief parameters that efficiency.

The reflected electr amplified in a casc multiplier of variable automatically variable is such that at low level high and at high leve The action prevents i from obliterating the as in some earlier type

The over-all system unity gamma and is scenes illuminated wit 0.01 candles per squar gain of the multiplier at the 0.01 candle le creases to about 10 at level. By placing an the tube the image sig fied above the noise level placed on outside condu interference will be pic

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The search channel co narrow non-conducting t ing mercury at constan Two electrodes, at ends of ameter, pick off the emf by the moving conductor in the magnetic field un A ratio of 10 to 1 betwe length and diameter (0.2 mm) has been found satis

Induced emf is given $\mu Hdv \times 10^{-8}$ volt, where separation of electrodes of the tube), v is the aver ity of mercury flow (rega velocity distribution), a oersteds is the componen magnetic field mutually pe lar to the channel axis and

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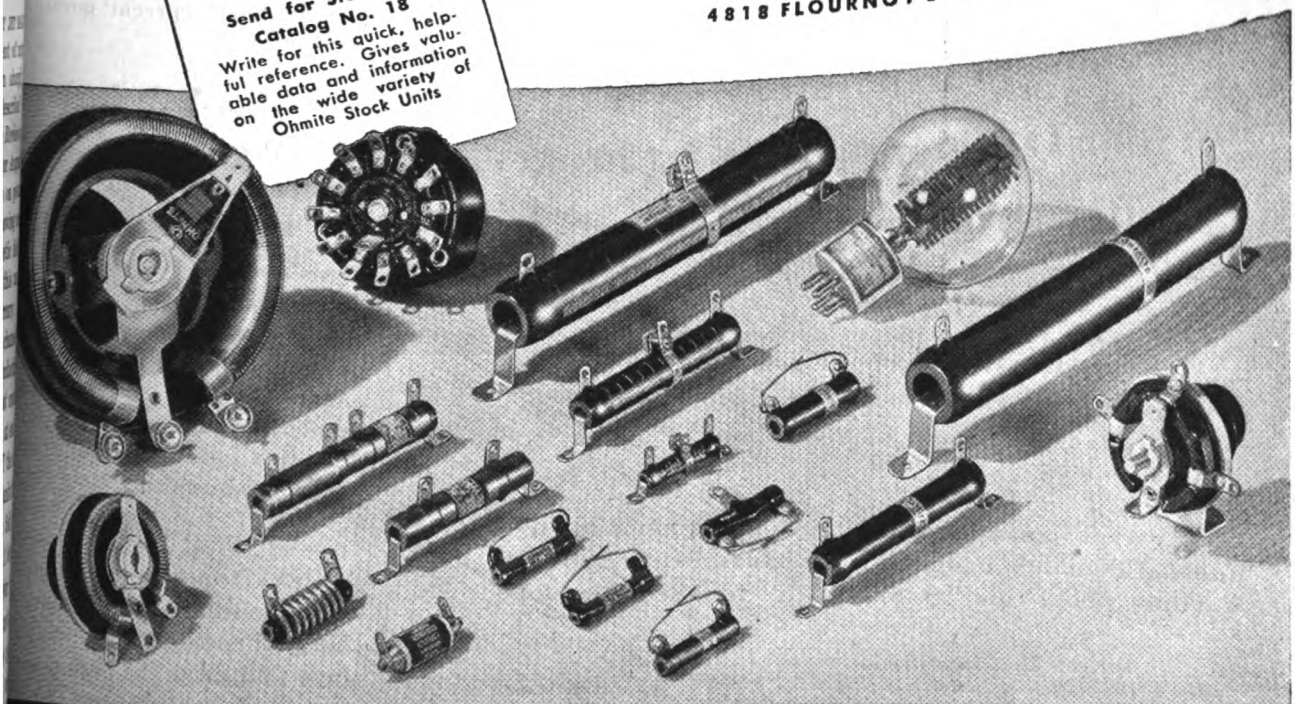

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• • •

High-Frequency Deflection System

By GUNTHER RUDENBERG
Harvard University
From Jour. of Applied Physics, May

THEORETICAL DESIGN considerati for the deflection system of a c ode ray tube to be used at high f quencies include the driving am fier output, the sensitivity of deflection system, and the arran ment of the system.

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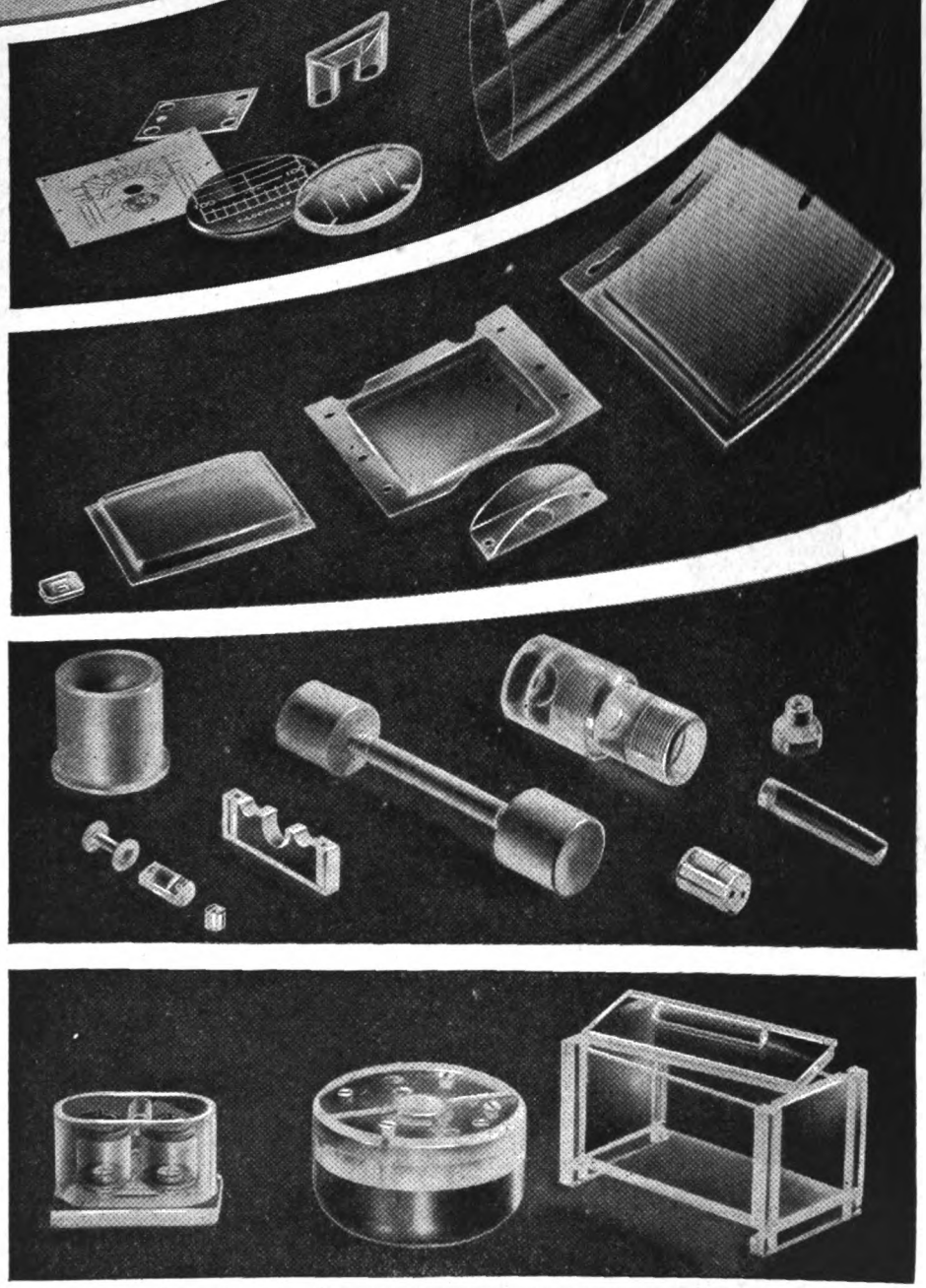

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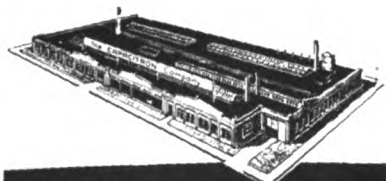

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cluding both that of th
and of the deflection sy
the peak output voltage
the upper frequency li
amplifier; i.e., the half-
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From this figure of m
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amplifier can be tuned.

Deflection Sensitiv

If, for small transit t
deflection field is uniform
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tial V with which the elec
enters the deflection fiel
stant, the deflection angle
beam produced by the
field is, from electron

$$\theta = (1/2V) \int_{Z_1}^{Z_2} e dz$$

where Z_1 is the position o
ginning and Z_2 the endin
deflection field as seen by
tron beam, and ϵ is the pe
lar component of the elec
along the path of the beam

From Gauss's theorem
to the plane of the path
beam within the deflecti
area, we obtain

$$\rho/\epsilon_0 = \int_{Z_1}^{Z_2} e dz$$

in which ρ is the charge
width of the plates and
permittivity of the space
the plates. If E is the
between the plates, and c
capacitance per unit width
to that portion of the elect
field that the beam traverse

$$\theta = Ec/2V\epsilon_0$$

This equation shows that,
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capacitance per unit width

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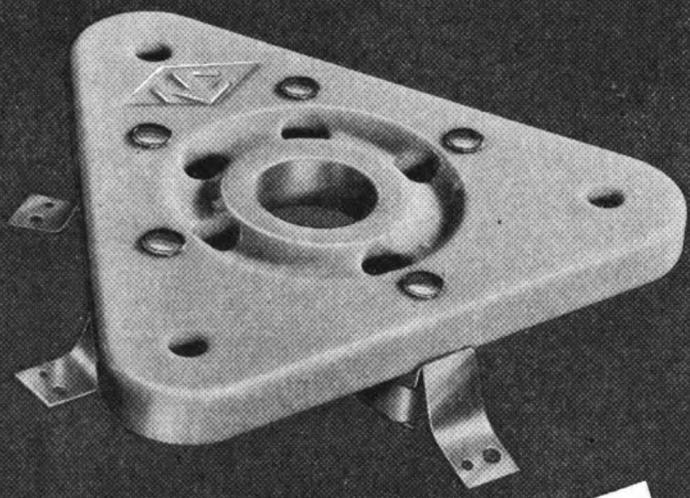
For Eimac's



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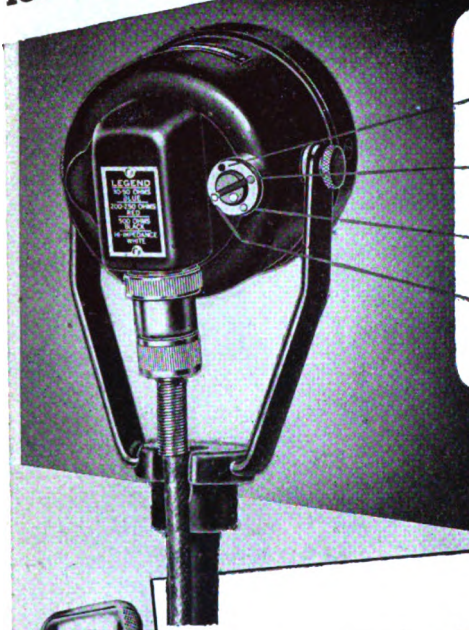

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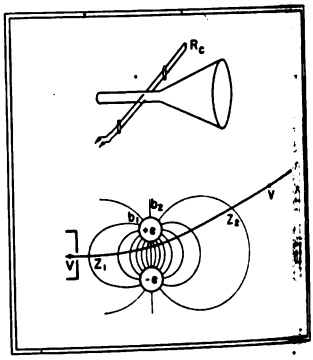
gives the same deflection. This capacitance takes into consideration the fringe effects in the path of the beam.

From Eq. 1 and 2 we find that $\theta = \rho/2V\epsilon_0$. This result shows that the deflection angle depends on the internal charge per unit width that can be placed on the system, and upon the axial accelerating potential, regardless of the configuration or potential of the deflecting system. The aims in designing either a deflection system or its amplifier are thus to decrease the beam accelerating potential at the deflection system and to increase the internal charge per unit width of the system.



At the top is a parallel-wire line used as the deflection system of a cathode-ray tube. The line can be terminated in its characteristic resistance thereby giving a system having an impedance independent of frequency. At the bottom is the deflection field established by the line. The length of the field is comparable to the wire spacing

For a given total charge, the deflection angle can be increased by making c large compared to the total circuit capacitance. Instead of making the deflection plates as small as possible as has heretofore been suggested, they should be designed to have large capacitance especially if the cathode-ray tube is to be connected to an amplifier which has some capacitance and can supply only a limited charge for the deflection system.

Parallel-Wire Line for Deflection

The factor c/ϵ_0 in Eq. 3 is a dimensionless quantity. Thus once the shape of the deflection system has been determined, its sensitivity

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—as long as transit-time effects do not enter—has been determined. However, because the axial length of deflection systems that use pairs of plates flared at their ends and the inductance and capacitance of their leads enter at high frequencies, the deflection is reduced.

Both transit time and lead effects can be reduced by using a closely spaced, parallel-wire line as illustrated in the accompanying figure. The capacitance per unit length of such a line is

$$c = \pi\epsilon_0/\cosh^{-1}(d/2r)$$

where r is the radius of the wires and d is their spacing. From Eq. 3 their deflection is

$$\theta = \frac{E}{2V}\frac{\pi}{\cosh^{-1}(d/2r)} \simeq \frac{E}{2V}\frac{\pi}{\ln(d/r)},$$

the approximation being valid for large (d/r).

The electrostatic field is mainly concentrated within a distance equal to the wire spacing. Thus the significant part of the transit time is that time required for the beam to cross a space of the same order of magnitude as the wire spacing.

Use of Parallel-Wire Deflection System

For measurements at fixed, high frequencies the parallel wires can be tuned, and by proper adjustment of the tuning a voltage maximum can be located at the point where the beam travels between them. Owing to the low losses of such a line, very high maximum of charge and voltage can be obtained thus ensuring a maximum deflection.

For wide-band operation, the deflection system should be terminated in its characteristic impedance. A greater power input to the deflection system than for the tuned condition will be required, but the system will present a pure resistance load at all frequencies. The surge resistance of a nonresonant line is

$$R_s = 120\cosh^{-1}(d/2r) \text{ ohms}$$

Thus the deflection angle in terms of the input current $I = E/R_s$ to the line is

$$\theta = 60\pi I/V$$

We see that this deflection is independent of the relative line spacing and is primarily determined by the

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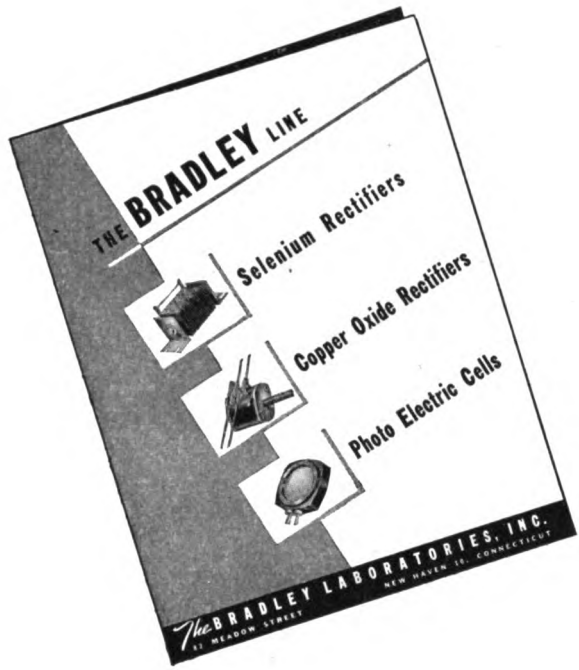

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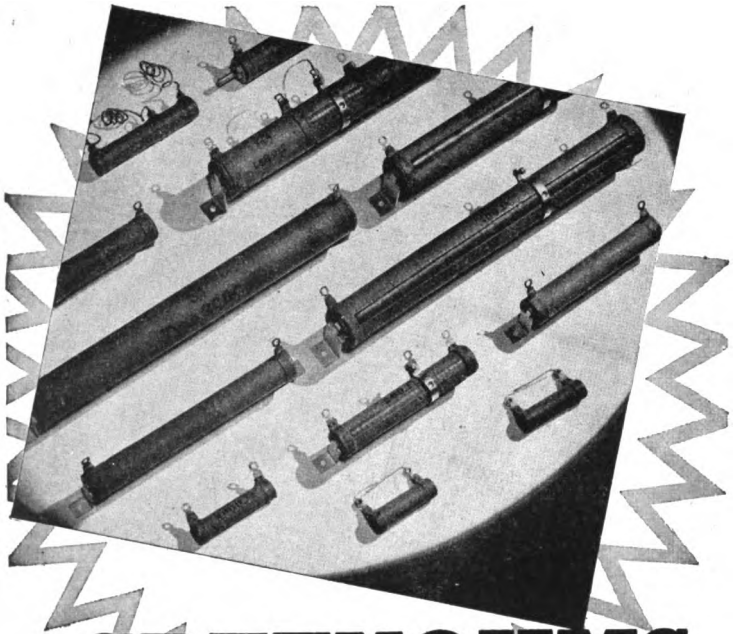

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current or charge on the deflection system.

The driving power for the nonresonant system is mainly dissipated in the terminating resistance and will be least when that resistance is smallest. This requirement indicates thick wires closely spaced. Where the wire diameter is too thick to be sealed into the glass walls of the cathode-ray tube, their cross section can be reduced thus offsetting the effect of the added dielectric of the glass on the characteristic impedance.

Contrasted to the conventional deflection-plate system in which a reactive power proportional to frequency is required, the parallel-wire system requires a resistive power that is independent of frequency. In the study of transients this advantage plus the absence of resonances make the parallel-wire deflection system very useful. If closely spaced wires are used, the low transit time enables absolute voltage measurements to be made at high frequencies.

• • •

Microanalytic Measurement of Oxygen Production

By PETER PRINGSHEIM

Ray Control Company
Pasadena, California

A METHOD FOR MEASURING the production of very small quantities of oxygen has been developed in collaboration with J. Franck and Dolores Terwood in the laboratory of the Fels Foundation in the Department of Chemistry of the University of Chicago.[1] The method is based on a phenomenon discovered by Kautsky[2] and permits measuring quantitatively the production of 10^{-9} cc per second of O_2 at atmospheric pressure.

Preparation of Posphor

Kautsky found that if a dye such as trypoflavine (acriflavine) is absorbed on silica gel and the gel is highly evacuated, the dye becomes phosphorescent when irradiated with light from an incandescent lamp, the afterglow being visible for about 10 seconds after the end of the irradiation. This phosphorescence is not affected by the presence of very pure N_2, H_2, CO_2, CO

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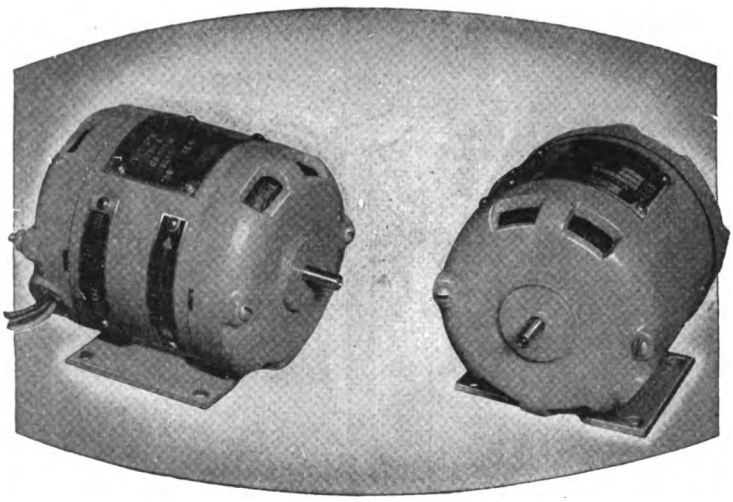

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or a rare gas, but it is very strongly quenched by the presence of the smallest quantities of O_2.

The phosphor, the phosphorescent gel with adsorbed dye, is prepared by immersing carefully purified silica gel in a dilute aqueous solution (0.5 normal) of the dye during a period of a few hours, keeping the solution in the dark. The grains of the gel should have a diameter of about 1 mm. After being dried superfically, a small quantity of the phosphor is inserted into a glass tube and evacuated during several hours to the highest attainable vacuum, while it is heated to 350°C. From there on, the phosphor must be protected against contamination with oxygen at high pressure. If it should come into contact with atmospheric air, the high temperature, vacuum treatment must be repeated.

Phosphoroscope

For quantitative measurements the tube containing the phosphor is placed between the discs of a Becquerel phosphoroscope the arrangement of which is shown in Fig. 1. The phosphor fills a tube of 4 mm

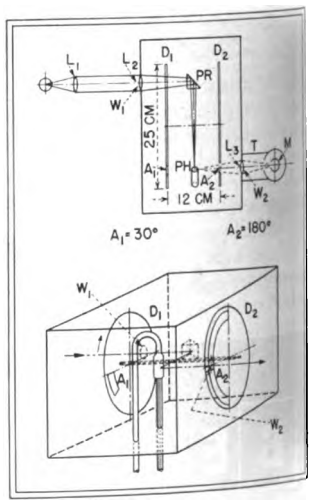

Fig. 1—Phosphoroscope in which oxygen sensitive phosphorescent dye is illuminated, the illumination shut off, and the reradiation directed to a photo tube

inner diameter and a length of 20 mm and is held in position by nickel gauze.

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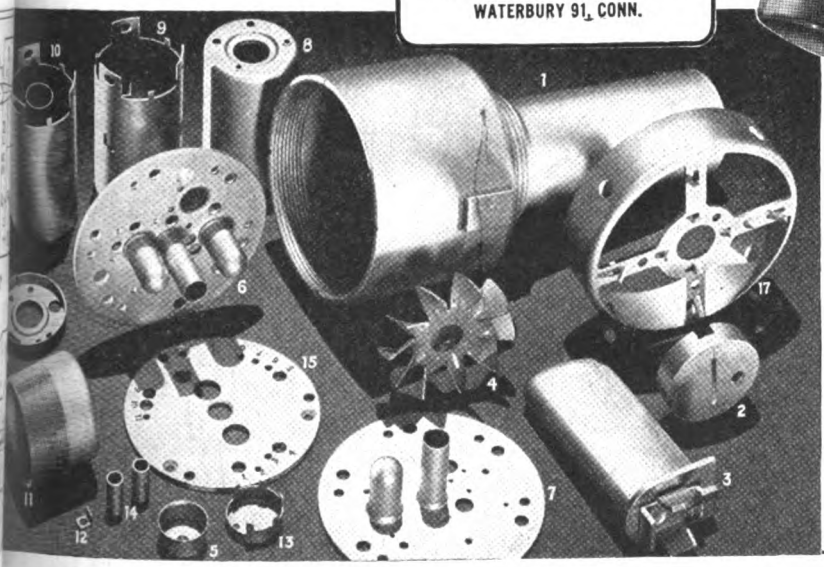

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the phosphoroscope through a window W_1 and the aperture A_1 in the first rotating disk D_1; the phosphorescent light is transmitted through window W_2 and aperture A_2 in the second rotating disk D_2. Apertures A_1 and A_2 are adjusted so that W_1 is completely screened by D_1 before A_2 opens window W_2. No light can fall on the phosphor except the radiation transmitted through W_1 and A_1.

The phosphor is excited by the radiation of a General Electric Mazda Projection lamp (6 v, 18 a) the current of which is supplied by a transformer connected to the houseline through a voltage regulator. The light is made parallel by a lens L_1 of small focal length so

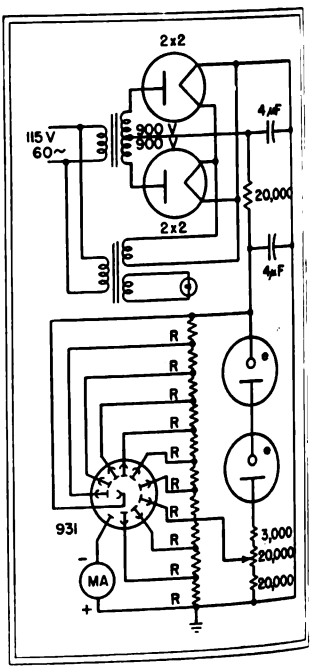

Fig. 2—Multiplier photo tube is used to operate indicating instrument

that the lamp can be located at a great distance from the phosphor and does not interfere with other parts of the apparatus. A lens L_2 is placed in front of the window W_2 and focuses the reduced image of the lamp filament on the phosphor; the totally reflecting prism PR is adjusted so that the light beam impinges on the phosphor container nearly at a grazing angle; the im-

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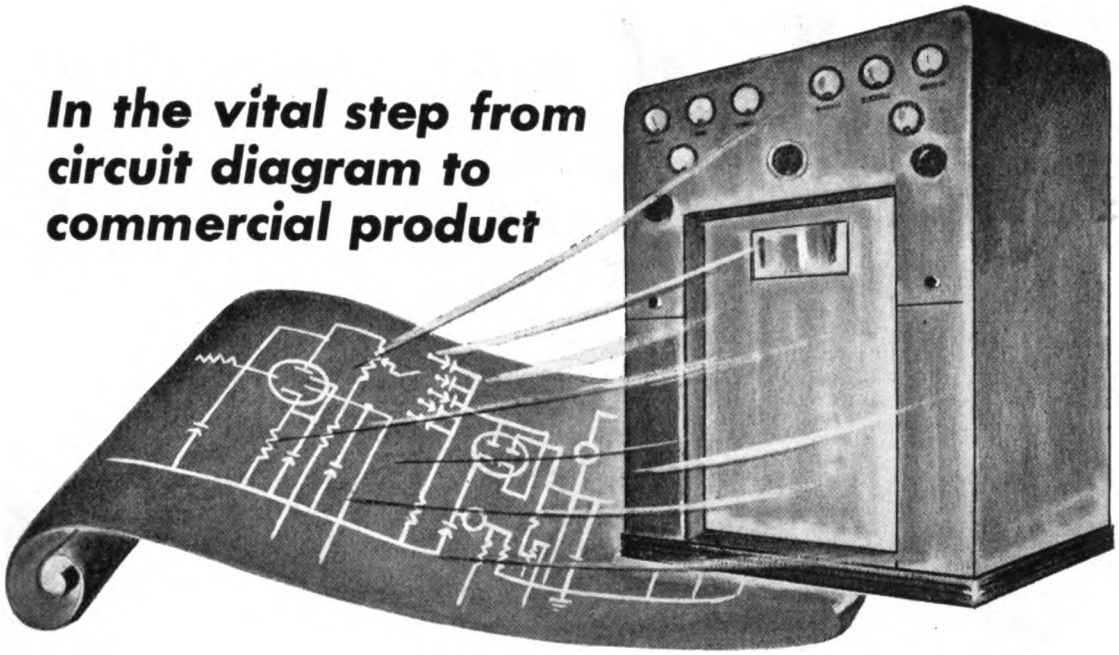

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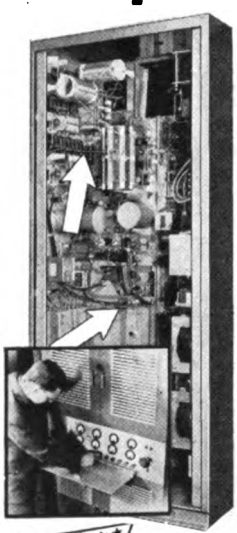

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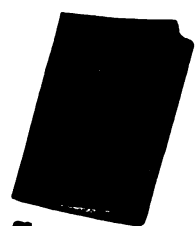

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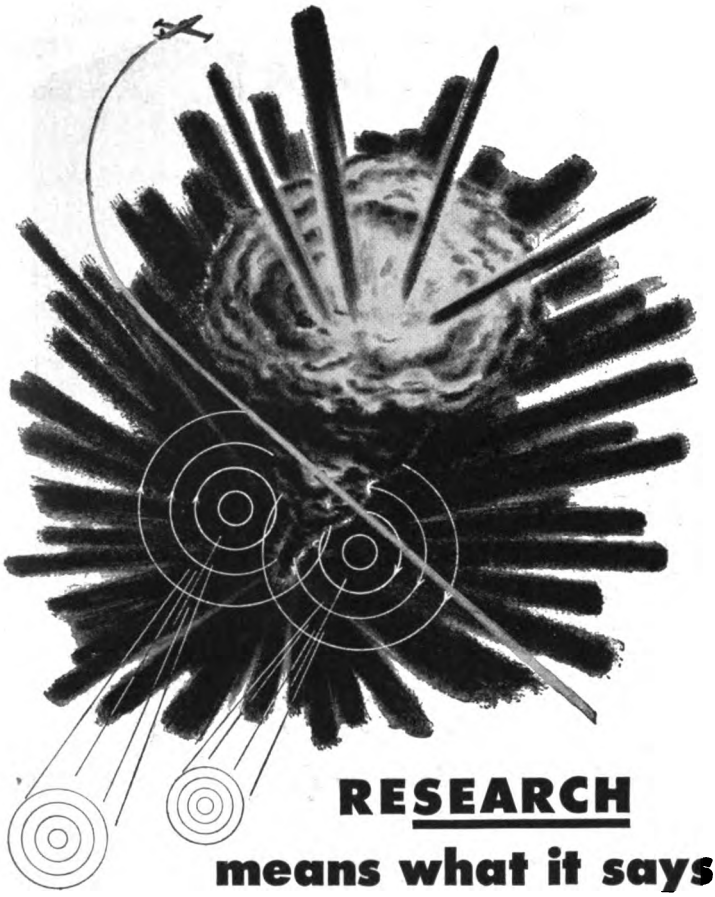

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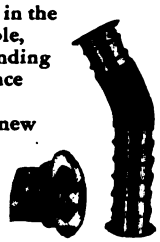

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age of the lamp filament has a surface of about 4 square mm. The light emanating from the phosphor is projected by a short focus lens placed in window W_2 into a photomultiplier. The latter is contained in a light tight housing with only a narrow opening for the entrance of the phosphorescence light; moreover, the opening is protected against stray light by a cylindrical tube T. Only light emitted by the phosphor after the end of the excitation period can enter the photomultiplier.

Electronic Circuit

The self compensating circuit used in connection with the photomultiplier and shown in Fig. 2 is of the type reproduced in "Experimental Electronics" by R. H. Muller, R. L. Garman and M. E. Drot (Prentice Hall, N. Y., 1943).

A part of the voltage divider consists of two VR 150 tubes. With a fluctuating line voltage the variations in the voltage of dynode 7 are, therefore, larger than those in the voltage of the other dynodes and can be used to counterbalance any changes in the latter.

The anode current was measured without further amplification by means of a Rubicon galvanometer of a sensitivity of 4.10^{-9} amp per mm. The inertia of the instrument was sufficient to give steady deflections if the frequency of the phosphoroscope was 6 flashes per second.

A photo-multiplier tube of the earlier type (R.C.A. 931) was at our disposal. Even with this tube we obtained sufficient amplification of the photocurrents produced by the phosphorescence by using 75 volts between adjacent dynodes, or 900 volts over-all. With the maximum voltage of 120 volts per step the anode output could have been increased more than tenfold. A similar high output could be obtained with the new 931-A tube at the normal 100 volts per step. Thus, either a galvanometer of lower sensitivity or a lower intensity of the exciting light could be used; the latter has some advantages because, after long and strong irradiation in the presence of O_2 the phosphor begins to deteriorate.

Measurements were made by tak-

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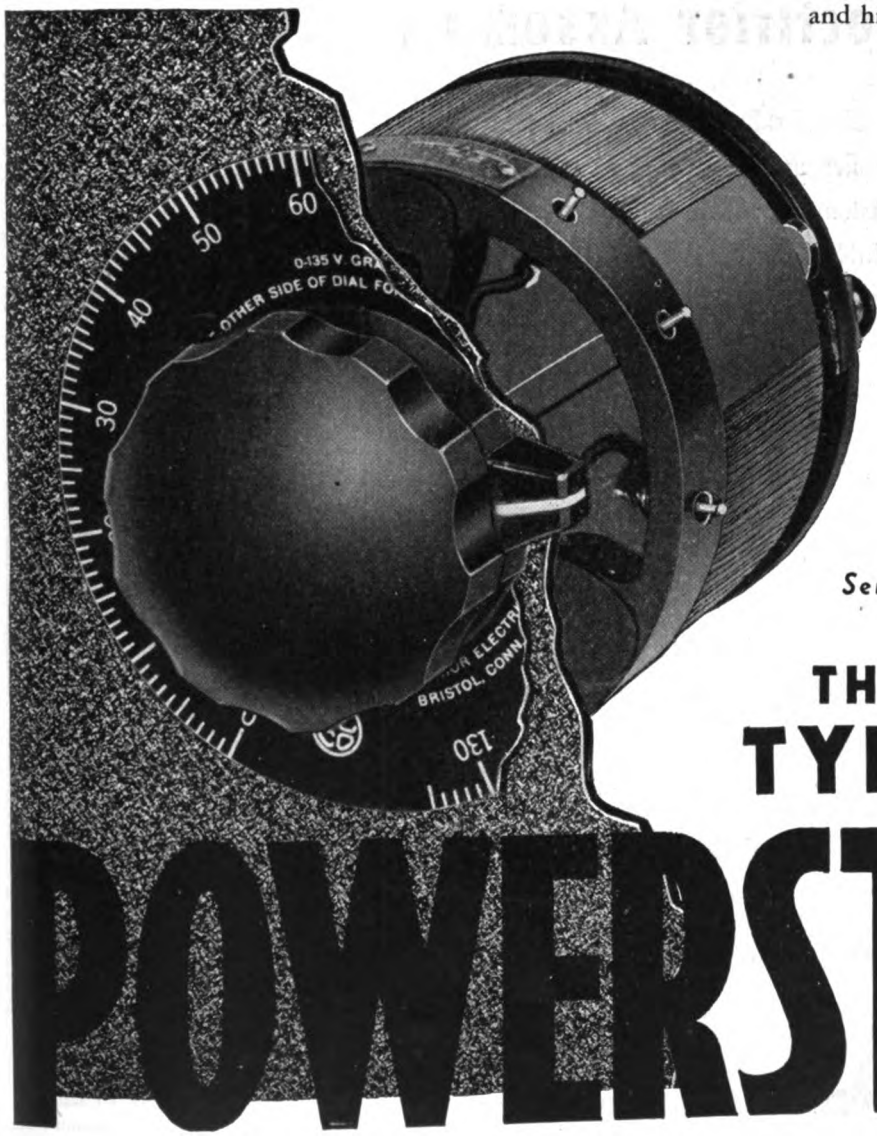
In announcing another new and smaller POWERSTAT variable transformer, SUPERIOR ELECTRIC COMPANY offers in the Type 20 all the desirable characteristics of larger POWERSTATS together with design features only applicable to a unit of this size. Use of special core materials and an unusual mechanical arrangement permits mounting on 1¼ inch radius. The space required behind the panel is only 3 9/16 inches. Although small in physical dimensions, the rating of type 20 illustrates the advanced design and high quality workmanship.



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Output: 0 to 135 volts, 3 amperes, 405 va.

Weight: 3.9 lbs.

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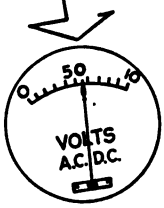

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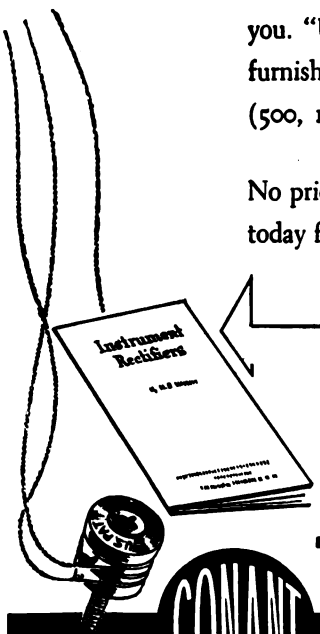

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ing a reading of the galvanometer deviation every two seconds and inserting the points in a diagram of galvanometer readings versus time. Since then a Esterline-Angus recorder has replaced the galvanometer. These points correspond to phosphorescence intensity which is a nonlinear function of the O_2 pressure. The dependence of phosphorescence intensity on oxygen pressure can be determined by introducing small quantities of oxygen into the highly evacuated apparatus and measuring their pressure by means of a McLeod gauge. The quenching efficiency of oxygen of a given partial pressure is practically unaffected by the presence of nitrogen. Fig. 3 shows a calibration curve.

Operating Technique

When not used for actual measurements, the phosphor was always kept in the dark. Under these conditions it could be used during many weeks. If, after a lapse of

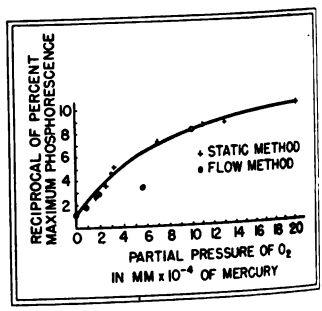

Fig. 3—Data from the phosphoroscope is converted from luminescence to partial pressure of oxygen by calibration curves similar to this one

time, it began to be less active, the height of the whole phosphoroscope with respect to the phosphor could be altered by a few millimeters, and a fresh spot of the phosphor gave again the former maximum phosphorescence.

The tube with the phosphor formed a part of a system which could be either connected to a diffusion pump or be flushed with N_2 or some other gas transporting small amounts of oxygen. Water vapor in the carrier gas must be frozen out in a trap cooled with liquid nitrogen before the gas reaches the phosphor. The carrier

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ELECTRONIC EQUIPMENT EDITION

DEC. *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1945

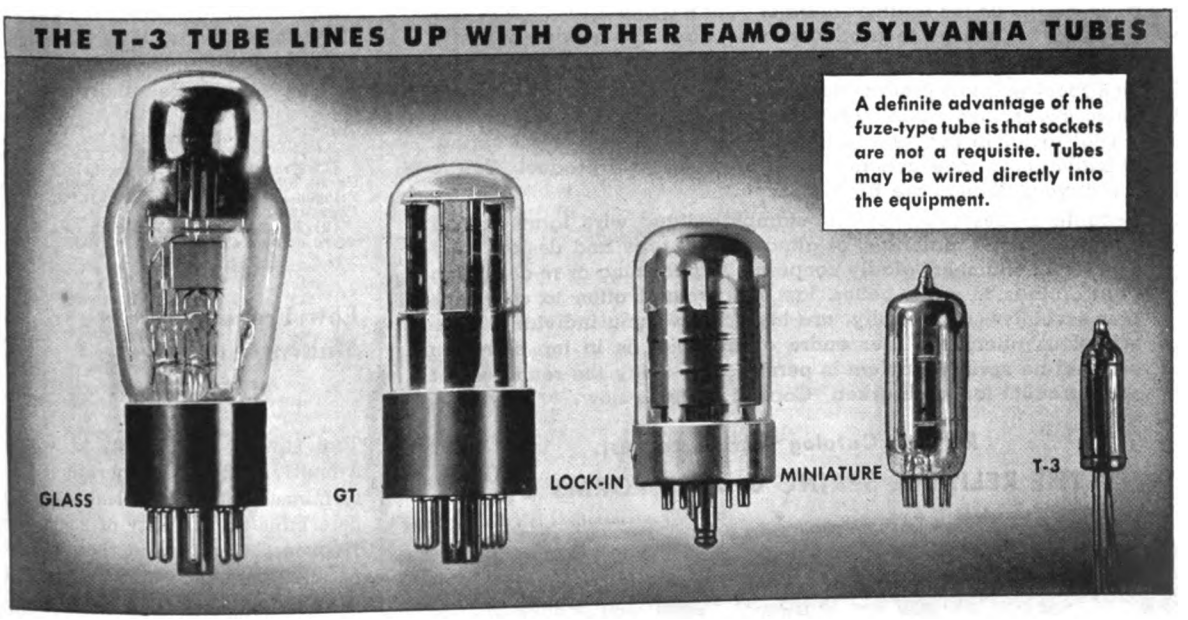
NEW, SENSATIONALLY SMALL SYLVANIA TUBE WILL PERMIT RADIOS OF CIGARETTE-PACK SIZE

Fuze-Type Tube Adaptable To All Battery Sets

Sylvania Electric announces a revolutionary new radio tube, the size of a peanut, which is as significant to the development of sets as the famous Sylvania Lock-In Tube.

Originally designed as the T-3 fuze-type tube, this tiny electronic unit is the commercial version of the radio proximity fuze tube developed by Sylvania. These tubes are being made in low-drain filament types. They have long life and are so rugged that they won't break when dropped. Their low-drain characteristics take advantage of a new miniature battery developed during the war — permitting the design of radios ranging from the size of a package of cigarettes up to a deluxe farm receiver.

The new, tiny, complete electronic unit will provide electrically and mechanically superior features similar to the Sylvania Lock-In Tube. Since the T-3 type of tube was originally designed to withstand the shock of travelling inside a spinning artillery shell, it will be even more rugged than the Lock-In, which has become known for its superiority for all types of sets.



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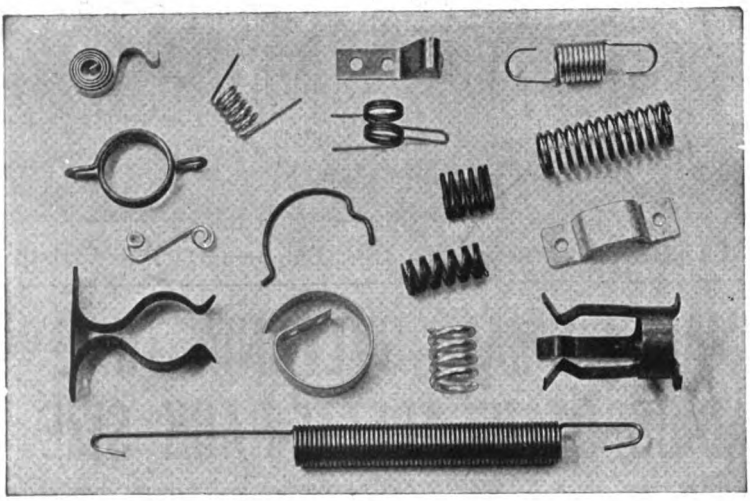

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gas itself, e.g. N_2 or H_2, must be of the very highest purity.

The method loses its sensitivity with increasing oxygen pressure; at pressures above 10^{-3} mm the phosphorescence is already quenched so much that a further increase in oxygen concentration has only a relatively small effect.

The quantity of oxygen produced per minute can be calculated from the partial pressure of oxygen measured during a certain period and the rate of flow, which in our experiments was only 3 cc per minute as controlled by a bubble counter. Because of this small rate of flow, the method becomes exceedingly sensitive as far as the rate of oxygen production is concerned.

It must be conceded that the quenching of the trypaflavine phosphorescence by oxygen does not yield absolute quantitative values with an accuracy of more than about ± 50 percent if the calibration curve is not frequently controlled, because the sensitivity of the phosphor is not constant. However, in many cases the order of magnitude of the oxygen production and its relative changes during a series of experiments will be all that is desired and, at any rate, no other method is available that could yield similar results with comparable ease and in as short a time.

References

(1) Franck, J. and Pringsheim, P., *J. Chem. Phys.* 11, 21, 1943; Pollack, M., Pringsheim, P. and Terwoord, D., *J. Chem. Phys.* 12, 295, 1944.
(2) Kautsky, H. and Hirsch, A., *Zs. f. anorg allgem. Chem.* 222, 126, 1935.

• • •

Low Frequency Multivibrators

By Carl J. Quirk
Signal Corps

The lowest frequency at which a multivibrator will operate is determined by capacitor leakage. To determine the stability of such low-frequency circuits and their lowest possible frequency, an investigation using standard parts selected at random was conducted.

Basic Circuit

A simple free-running multivibrator shown in the accompanying illustration was used as the start-

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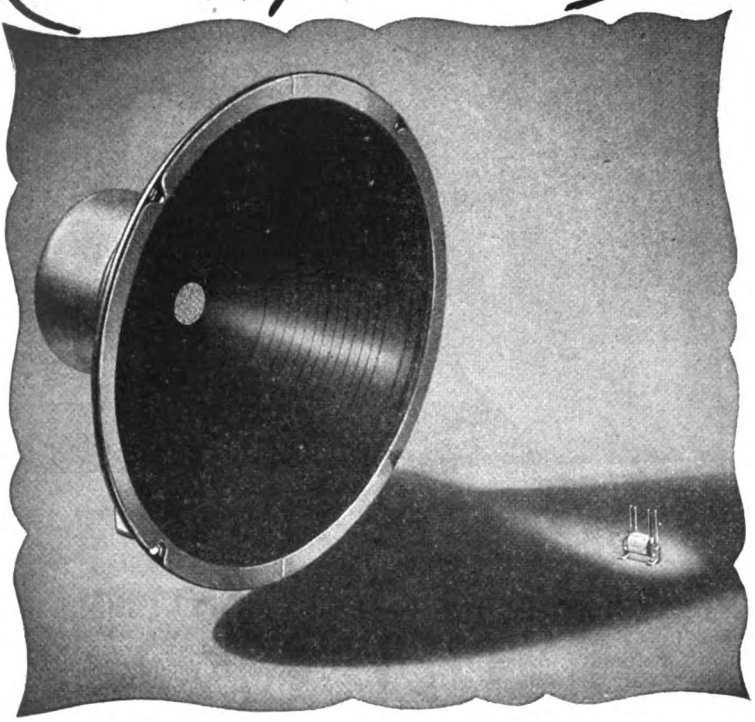

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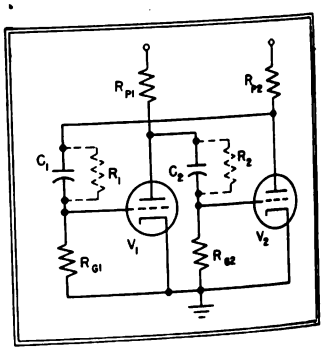
ing point. Disregarding for the present the capacitor leakage resistance shown dashed, the duration of a cycle is expressed by $T = R_{G1} \cdot C_1 R_{G2} \cdot C_2$, if $R_{G1} > R_{P2} \cdot R_{V2}/(R_{P2} + R_{V2})$ and $R_{G2} > R_{P1} \cdot R_{V1}(R_{P1} + R_{V1})$ where R_{V1} and R_{V2} are the d-c resistance of V_1 and V_2 respectively. If resistances are given in megohms and capacitances in microfarads, the period will be in seconds.

Because these conditions are usually satisfied in multivibrators, this order of magnitude equation can be used. As will be shown later, results calculated by this equation will not always be accurate, but for the purpose of this discussion they will be close enough.

Multivibrator Operation

To illustrate the manner in which the leakage of the coupling capacitors limits the lowest frequency of operation, the function of the circuit is reviewed. An increase of



In the multivibrator used to determine the lowest frequency of operation, grid resistors were finally omitted and the leakage of the capacitors used to perform their function

current in V_2 lowers its plate voltage. This reduction in plate voltage is coupled through C_1 to the grid of V_1 thereby reducing the current in V_1 and causing an increase in the plate voltage which in turn is coupled to the grid of V_2 through C_2 causing the plate current of V_1 to further increase. This series of events continues until V_1 is cutoff, at which time V_2 will be drawing a large plate current. A very short time compared to the complete cycle is required for this action.

The effect is a sudden change in voltage across C_1 from the full

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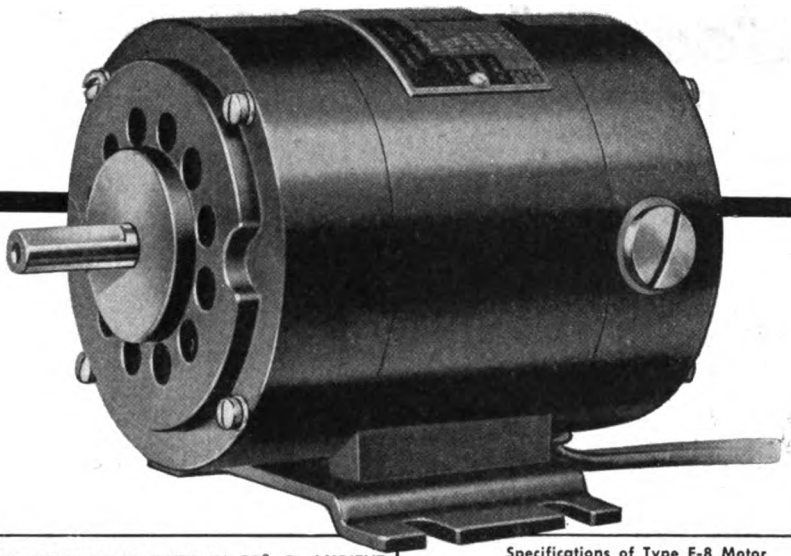

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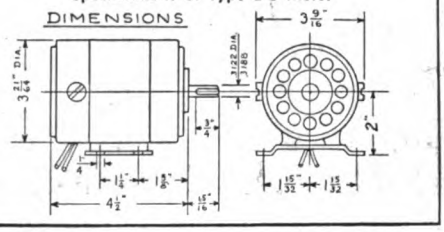
R.P.M.	7500	5800	3800	2800	1750
Amps Input	.8	.67	.46	.38	.32
Starting Torque in % of F. L. Torque	200 min.	200 min.	200 min.	200 min.	200 min.

Specifications of Type E-8 Motor

DIMENSIONS



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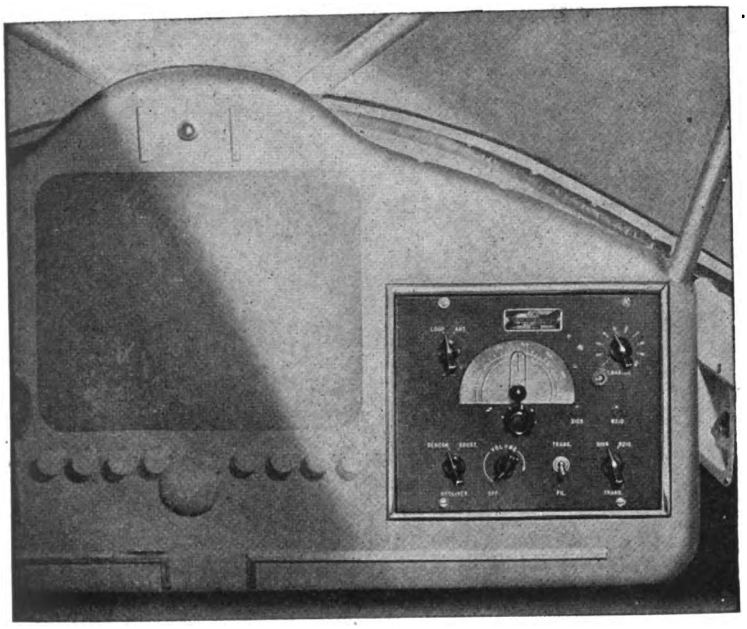

Here is the ERCO FLIGHT MODEL 60 Transmitter-Receiver installed in the Fairchild 24 of Sperry Gyroscope Co.

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plate supply voltage to a much lower value. But this reduction in voltage across C_1 cannot occur instantly, thus the voltage drop across R_{G1} due to the discharging current of C_1 causes V_1 to go rapidly to cutoff and remain cut off until the discharge current becomes low enough so that the voltage across R_{G1} is equal to the cutoff bias of the tube, at which time the circuit will again switch and cause V_2 to become cut off and V_1 to conduct.

The period during which V_1 will be at cut off will be designated as T_1 and determined by the product $R_{G1}.C_1$. This condition will hold true if R_{G1} is much greater than the parallel resistance of R_{P2} and R_{P2} (as mentioned above) and much less than the leakage resistance of the capacitor C_1 itself. In most low frequency multivibrators the first condition will be satisfied but the second will have to be determined by trial and error. Likewise the period during which V_2 will be at cutoff will be designated as T_2 and determined by the product $R_{G2}.C_2$.

Effect of Capacitor Leakage

Referring to the illustration, note the resistance R_1 and R_2 which represent the leakage resistances of the associated capacitors. Because means to measure leakage resistances of capacitors is not available to most experimenters, the only way one can be sure whether this leakage is going to affect the operation or not is to actually build the circuit and test it. A number of combinations were tried and the results presented in Table I. In all combinations R_{P1} and R_{P2} are 0.5 meg, the plate supply to the 6SL7 tube is 250 volts.

In the first six tests it was decided to determine how large R_{G1}

Table I—Measured periods of long time-constant multivibrators

$C_1=C_2$ in μf	$RG_1=RG_2$ in megohms	T_1 in seconds	T_2 in seconds
0.5	1	1.5	1.5
0.5	3	4.5	4.5
0.5	5	8	7
0.5	10	15	15
0.5	15	24	19
0.5	18	27	24
1.0	18	50	50
8.0	18	170	153
16.0	18	345	235
16.0	56	1080	1140

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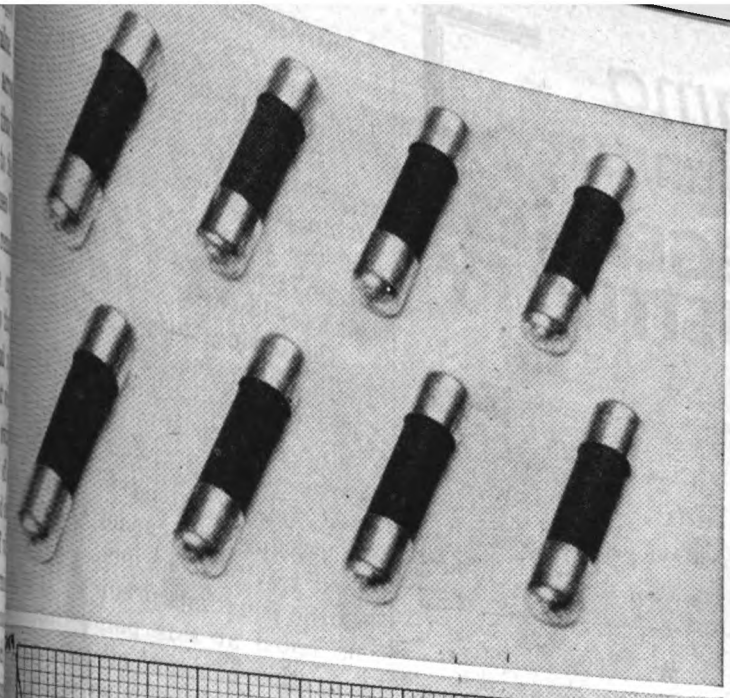

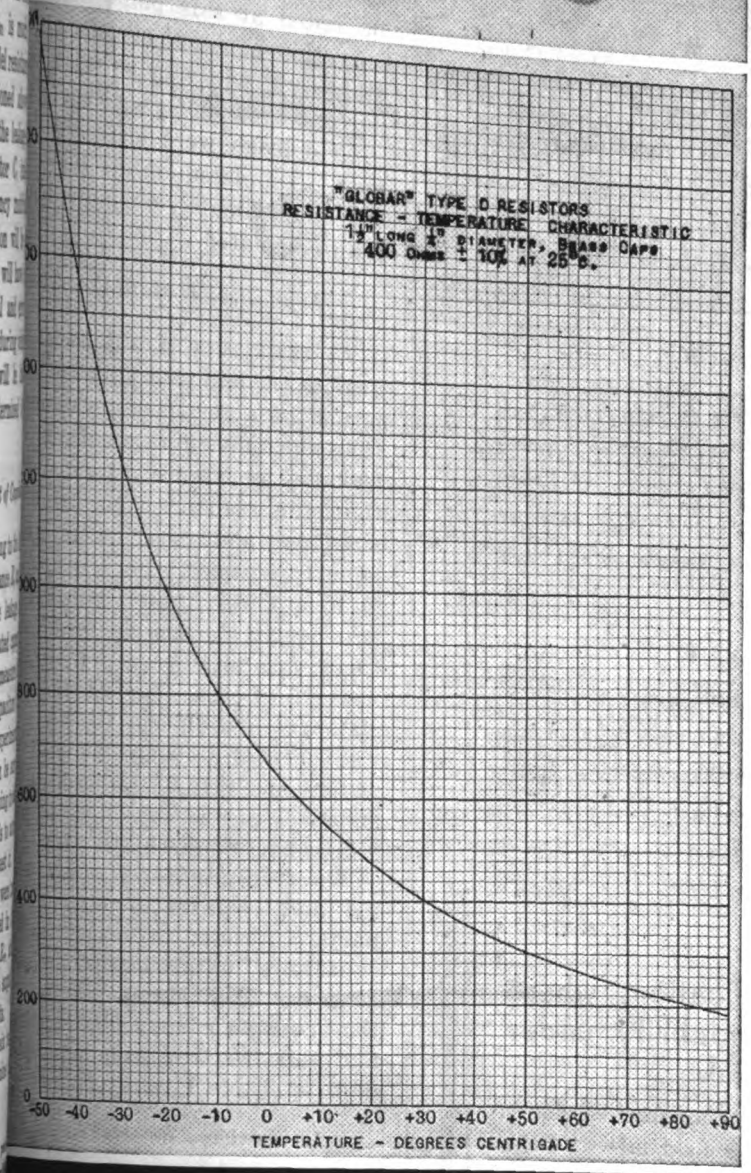

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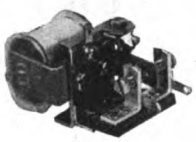
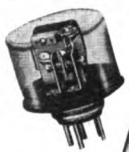


TYPE 4F

This is the Series 4 relay with open frame construction. It is compact (1⅝" x 1⅜" x 1⅝"), fast (2 - - 3 milliseconds with sufficient power), sensitive (.010 watts minimum).

TYPE 4A

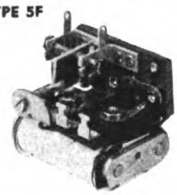


TYPE 4R

TYPES 4A AND 4R

These are the basic Series 4 construction with enclosures. The 4A is 2⅛" diameter and 2⅛" high, the 4R ½" x 1½" x 2⅝". Both have a 5-pin plug in base. The 4A can be sealed (4AH).

TYPE 5F

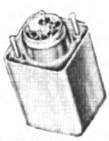


TYPE 5F

This is the Series 5 relay with open frame construction. It is exceedingly sensitive (.0005 watts minimum), very rugged, precise in operation even under extremes of temperature and vibration.

TYPE 5R

TYPE 4 (or 5) RJLB2



TYPES 5R AND 4 (or 5) RJLB2

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could be made before the leakage of 0.5 μf capacitors would affect operation. However, as can be seen from Table I, the leakage resistance of the capacitors is much greater than 18 meg because the period increases linearly with resistance.

Increasing the capacitors to 1 μf with the same grid resistors increased T to twice its previous value. However increasing the capacitors to 8 μf only increased T five times (instead of eight), but increasing the capacitance in the next test to 16 μf doubled the time as the equations predict. It should be noted at this point that these long time-constant circuits are not stable and will vary as much as 30 percent over short periods of time.

Grid leaks were increased to 56 meg. Tabulated results show that T is approximately 6 minutes longer than calculated.

Long Period Multivibrator

At this point it was decided to design a multivibrator with a period of a few hours. Assuming that the capacitors would have a leakage resistance much higher than the resistors, very large resistances and capacitances would have to be used. For example, to build a multivibrator with a T of two hours, R_{G1} and R_{G2} would have to be 225 meg each if C_1 and C_2 were 16 μf each. Because these resistances are difficult to obtain, it was decided to omit the grid resistors and rely on the leakage resistances of the capacitors to provide capacitor discharge paths.

The resulting circuit is very simple and requires a minimum of parts. Results of using various capacitors in this circuit are presented in Table II. The circuit used the same plate supply, plate loads, and tube as that from which the data of Table I were obtained.

Leakage Resistances

With R_{G1} and R_{G2} omitted from the circuit, it is relatively simple to determine the leakage resistances of the capacitors. Because the time involved in charging or discharging either capacitor is a function of both capacitance and the leakage resistance, $R_1 = T_1/C_1$, and $R_2 = T_2/C_2$. Values obtained will not

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could be made before the
of 0.5 μf capacitors would
operation. However, as can
from Table I, the leakage
of the capacitors is much
than 18 meg because the
creases linearly with resist

Increasing the capacitor
with the same grid resist
creased T to twice its
value. However increasing
capacitors to 8 μf only increa
five times (instead of eight
increasing the capacitance
next test to 16 μf doubled the
as the equations predict. It
be noted at this point that
long time-constant circuits are
stable and will vary as much
percent over short periods of

Grid leaks were increased
meg. Tabulated results show
T is approximately 6 minutes
than calculated.

Long Period Multivibrator

At this point it was decid
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Leakage Resistance

With R_{g_1} and R_{g_2}
the circuit, it is relative
to determine the leakage
of the capacitors. Because
involved in charging or
either capacitor is
both capacitance and
resistance, $R_l = T_1/C_1$
$= T_2/C_2$. Values

December 1945

SPEER GRAPHITE ANODES DON'T WARP

. . . when tubes are made

when tubes are used

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6. *Minimize bulb darkening and insula*
7. *Improve degassing qualities*
8. *Decrease gas troubles*
9. *Enhance tube appearance*
10. *Provide precise anode dimensions*
11. *Produce uniform tube characterist*
12. *Retain original dimensions in serv*
13. *Maintain normal tube characterist*
14. *Allow wide latitude of anode desig*

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be too accurate, but because in practical design of a very low-frequency multivibrator it is sufficient to know the approximate value of leakage resistance of the capacitors to be used, the measured results shown in Table II suffice.

Although in a conventional multivibrator designed for operation at very low frequency a 0.001 μf capacitor would not be used, capacitors of this value were checked to determine how closely the leakage of each checked with the others. As mentioned before, any long time-constant circuit will vary considerably from cycle to cycle, therefore it was difficult to decide how different the leakage values of these capacitors actually were. However, readings were taken at random and the results tabulated. The period of each combination runs fairly close to the others.

In test 4 the 0.001 mica capacitors were rated at 1200 d-c working volts which probably accounts for their higher resistance. In tests 5 and 6 the capacitors were increased five times but T did not increase five times because, as it is to be expected, as capacitance increases for the same voltage rating capacitors, the leakage resistance decreases. However, using higher capacitance capacitors increases the period somewhat. In test 11 the 0.5 μf capacitors were rated at 400 volts and were an inferior grade. This fact undoubtedly accounts for the much lower resistance of these units. All other capacitors were rated at 600 volts and were of good quality.

In several of the tests one capacitor of a combination had much greater leakage than the other. This phenomena is to be expected because any variation will appear as a greater percent of the period than it would with smaller capacitances.

Practical Circuit

With relatively small capacitors, fairly low frequency multivibrators can be easily built by omitting the grid resistors. This circuit fulfills the requirement of having a very low frequency and using small capacitors. With two 8.0 μf capacitors, a period of three hours can be realized.

It may be argued that a multivi-

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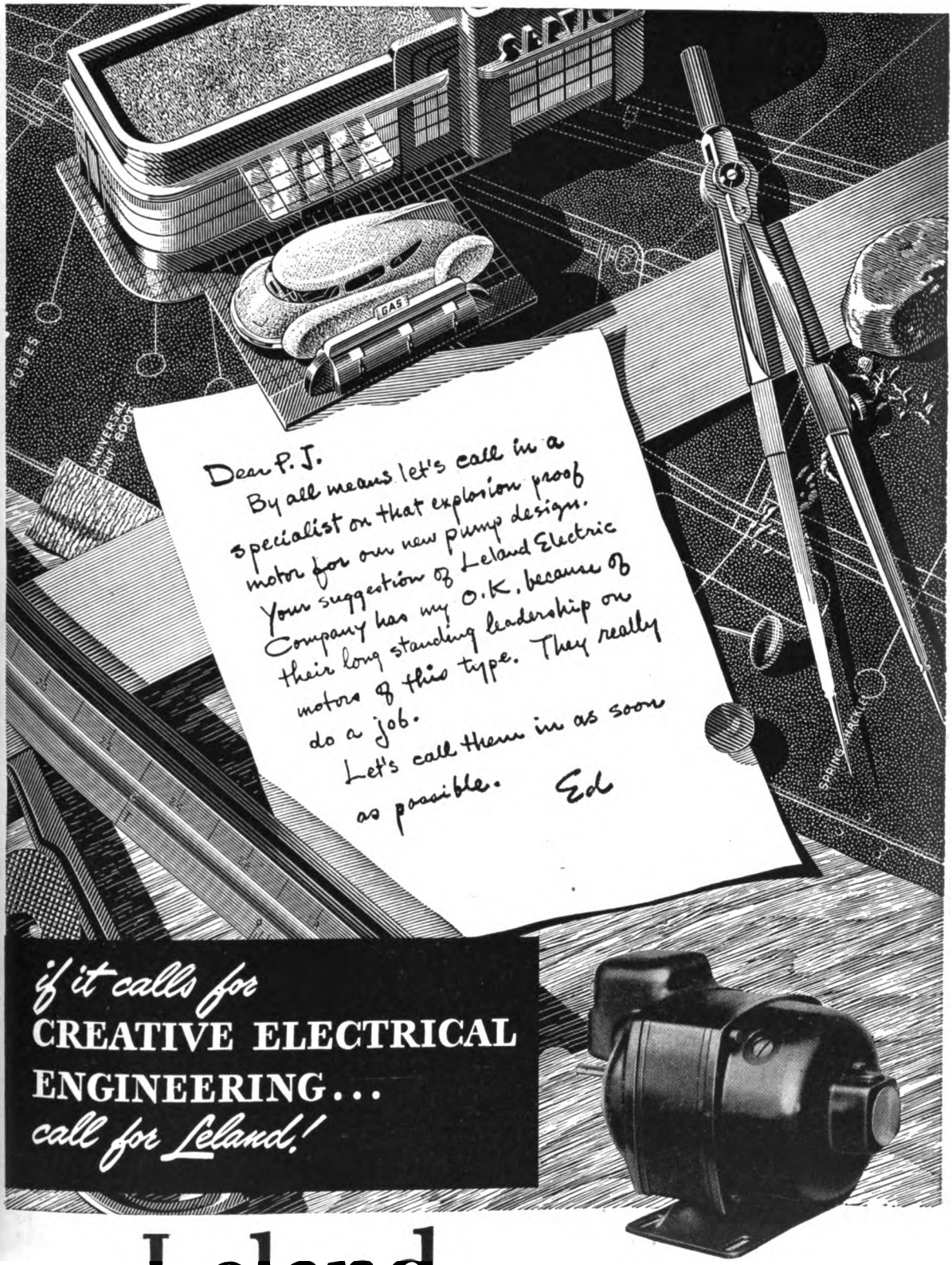

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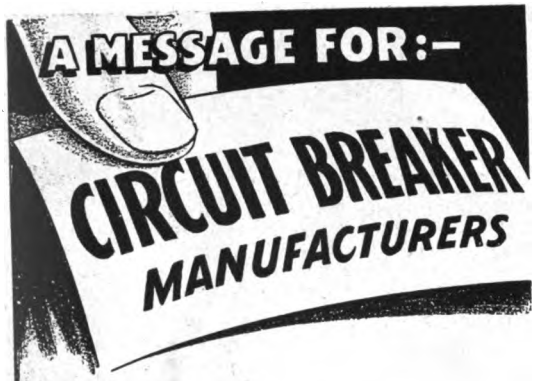

Many manufacturers now use a uniform size and shape of thermostatic bimetal element in building a "line" of circuit breakers covering a range of circuit ratings. This is made possible by selecting a type of bimetal based on its electrical resistivity. The following types cover a wide range of electrical resistivity values:

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125	Chace No. 6125
150	Chace No. 6150
200	Chace No. 6200
300	Chace No. 6300
400	Chace No. 6400
480	Chace No. 2400
650	Chace No. 6650
850	Chace No. 6850

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Manufacturers of
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brator in which the grid resistors are omitted will not be very stable in frequency. This is granted, but it is also true that if a multivibrator is designed with a period of one hour using capacitors of 16 μf and grid leaks of approximately 112 meg, it will be no more stable than one using two 0.1 μf capacitors without grid leaks. In either case if we desire a very stable multivibrator for low frequencies it will have to be synchronized.

There is a current path from the grid sides of the capacitors to the negative side of the power supply through the tube base and socket. If the leakage of this path is of the same order as that of the capacitors, it has as much to do in determining time constant as do the capacitor leakages.

Table II—Periods of Multivibrators Using Capacitor Leakage Paths

$C_1=C_2$ in μf	Type*	R_1	R_2	T_1	T_2
		in megohms		in min & sec	
0.001	tube	145,000	83,000	2:25	1:21
0.001	"	65,000	60,000	1:05	1:00
0.001	"	95,000	145,000	1:35	2:25
0.001	mica	197,000	126,000	3:17	2:06
0.005	"	27,600	24,000	2:18	2:00
0.005	"	20,600	52,000	1:43	4:20
0.01	"	30,000	125,000	5:00	10:25
0.1	tube	32,600	6,350	54:20	10:35
0.25	tube	10,080	1,080	42:00	4:30
0.25	"	308	2,440	1:17	10:10
0.5	"	100	136	0:50	1:08
8.0	can	375	1,222	50:	163:
8.0	"	990	562	132:	75:

* All capacitors are paper insulated unless otherwise stated

During measurements for Table II a change was made from a bakelite tube socket to a Steatite socket and no difference was noted.

• • •

Modulation by Feedback

By Robert C. Shaw
Bell Telephone Labs., Inc.
Patented June 26, 1945, No. 2,379,042

Modulation is accomplished by controlling the amount of negative feedback. The accompanying figure illustrates the general principle. The carrier is amplified in a low-distortion, stabilized, negative-feedback amplifier. The loss in the carrier feedback loop is varied in accordance with a modulating potential applied within the feedback loop, thereby producing a modulated wave in the output of the carrier amplifier.

Where the output voltage is represented by E, the carrier input to

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brator in which the ... are omitted will not ... in frequency. ... it is also true that ... is designed with a ... hour using capacitor ... grid leaks of approx... meg. it will be no more ... one using two ... without grid leaks. ... if we desire a very ... vibrator for low frequen... have to be synchron...

There is a current ... grid sides of the ...

Table II—Periods of Multivibrator ... Capacitor Leakage Res...

C in μf	C. Type*	R in megohms	I
0.001	tube	145,000	69.0
0.001	"	65,200	68.8
0.001	"	95,800	142.8
0.001	mica	197,000	70.0
0.005	"	37,000	30.0
0.005	"	38,600	32.0
0.005	"	30,000	150.0
0.01	"	32,000	1.70
0.1	tube	32,000	1.70
0.25	tube	10,000	1.00
0.25	"	200	1.00
0.5	"	100	1.0
8.0	mica	175	1.00
8.0	"	400	1.00

* All capacitors are paper sealed and ... dotted

negative side of the ... through the tube base and ... the leakage of the ... same order as that ... it has as much to ... time constant as ... leakages.

During measurements ... If a change was made ... tube socket to a ... and no difference was ...

Modulation by Feed...

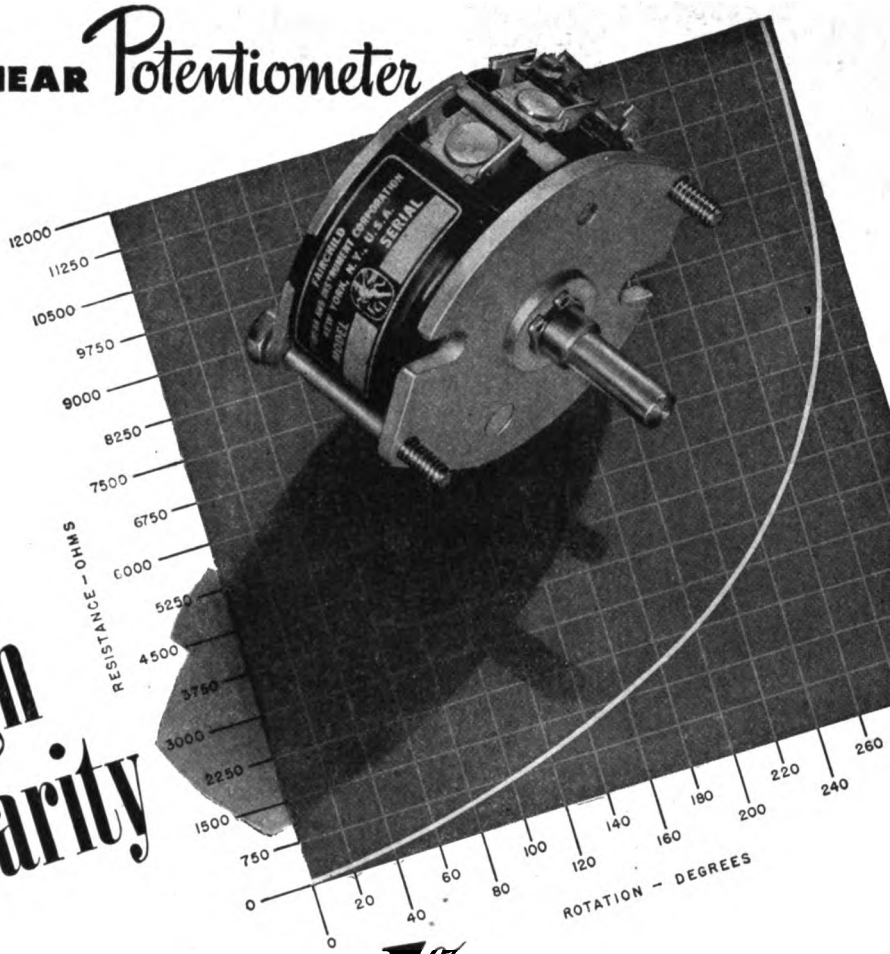
By Robert ...

Radio Television Labs ...
Published June 15, 1945

MODULATION is accomplished ... controlling the amplification ... feedback. The accompanying ... illustrates the process. ... The carrier is amplified ... distortion, stabilized ... back amplifier. The ... rier feedback loop is ... accordance with a signal ... tential applied within ... loop, thereby producing ... lated wave in the ... carrier amplifier.

Where the output ... resented by E, the ...

NON-LINEAR Potentiometer



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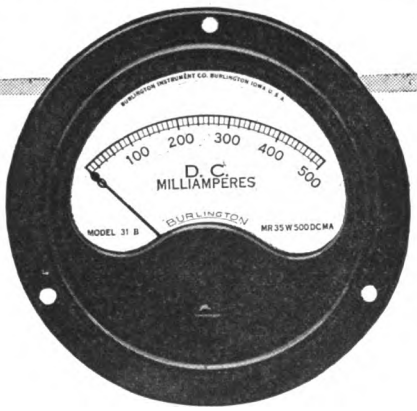

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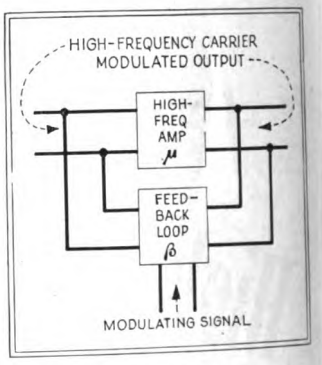
the high frequency amplifier is E_c, and the complex feedback factor is β; the output is given by $E = E_c/(-\beta)$ provided $|\mu\beta| >> 1$. A variation in feedback factor from approximately 22 to 35 db for an amplifier having $\mu = -1{,}000$ results in the carrier being modulated 67 percent in one particular application. With feedbacks of this order, the nonlinearity introduced



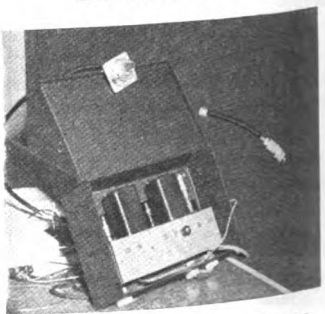
Basic circuit consists of an amplifier, a feedback loop, and a means of controlling the loss in that loop

by assuming that $|\mu\beta| >> 1$ gives distortion of only a few percent.

Modulation can be introduced in series with the grid bias of a variable μ tube in the feedback loop. It may be desirable to introduce nonlinearity in the modulation signal circuit to counteract nonlinearity in the modulator if $|\mu\beta|$ is not much greater than unity.

• • •

DOOR OPENER



Supersonic squealer actuated from car dashboard emits h-f sound from exhaust pipe that is picked up by a microphone to operate garage door opener. The system is made by Vendo Company of Kansas City

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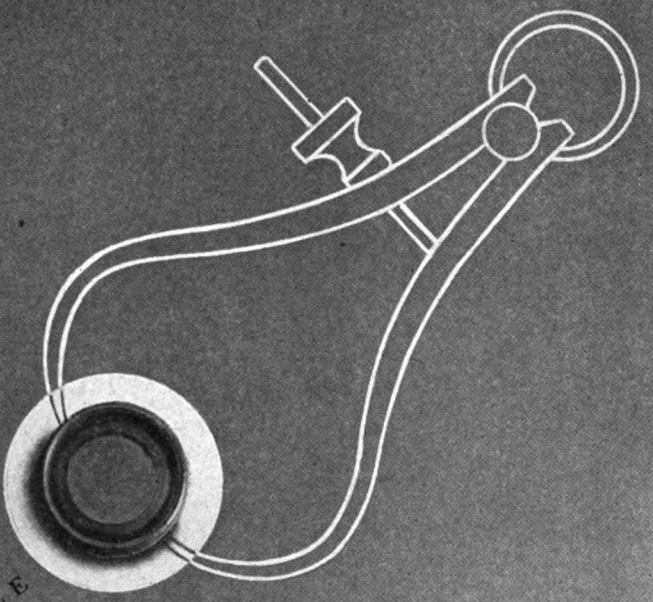

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NEWS OF THE INDUSTRY

Commercial radar progress; f-m receivers; reports on dielectric heating and wire recording; three lists of agents for surplus electronic equipment

CAA Radar for Airways is Approved by British

AT A RECENT British Empire Radio for Civil Aviation Conference held in London recently, several important points of agreement were reached which indicated complete accord with the Civil Aeronautics Administration on standards of airways aids and future developments. The U. S. delegation, headed by the Honorable Charles P. Taft and including representatives of the Army, Navy, Coast Guard, Radio Technical Commission and CAA, was invited to serve as observers but stayed to become active participants in the discussions and decisions.

The most important items of agreement reached at the conference were:

(1) The adoption of CAA-developed vhf static-free communications for airport and approach control. The frequencies used will be in the band 118-122 mc. Sufficient radio-frequency channels have been made available to accommodate all airports so that there will be no interference between airport traffic control stations. At present, only 278 kc is available for airport traffic control, whereas the vhf band will permit 20 channels to be used for this purpose. It was agreed that radiotelephone should be used in lieu of radiotelegraphy, thus speeding up operation of traffic in close proximity to terminal airports.

(2) The vhf two-course visual radio range developed by CAA was adopted as the primary short-range navigation device. This type of range produces two visual courses at 180 degrees which may be projected along an airway. Sector identification is also provided which advises the pilot of his position relative to the station and whether he is approaching or leaving the station. The course indications are shown on a right-left instrument on the instrument panel in the cockpit. Voice communication which provides weather and airway traffic control information is also obtained from the same facility. Several hundred of these facilities are now being installed on federal airways throughout the U. S.

(3) Radar techniques have been developed whereby a simple instrument on the panel of the airplane will provide a meter indication giving the number of miles to the radio range station or instrument landing localizer station to which the pilot is flying. CAA authorities regard this instrument as the most important use of radar in the cockpit to come out of the war.

(4) Use of radar search device to aid tower operators to monitor planes doing instrument approaches and to help in emergencies where plane equipment is not functioning or where the plane is not equipped with proper instruments. This is considered the most important ground application to come out of the war.

(5) Adoption of CAA three-element landing system consisting of glide path, localizer, and marker beacon.

Electronic Weapons

TO CONTINUE RESEARCH and development of weapons like the proximity fuze, Army Ordnance has selected the National Bureau of Standards to establish such activities on a permanent basis. Several other devices have been in the works but details have not been revealed.

Not only will the bureau study the application of new scientific knowledge to war uses but it will also undertake to study peacetime uses for the knowledge gained in development of weapons. Located in a half-million dollar laboratory scheduled to be finished this year, the activities will center in the Ordnance Development Division headed by Harry Diamond. Several hundred physicists, engineers, and technicians will constitute the staff, set up to draw upon the facilities and experience of the entire National Bureau of Standards.

International RMA

MUTUAL PROBLEMS were discussed at the Second Joint Conference held recently between the U. S. and the Canadian RMA's. Held at the West-

Directors of the U.S. and Canadian RMA's get together at lunch during the recent Second Joint Conference in Rye, N. Y. See if you can find W. R. G. Baker of General Electric and George Lewis of IT&T

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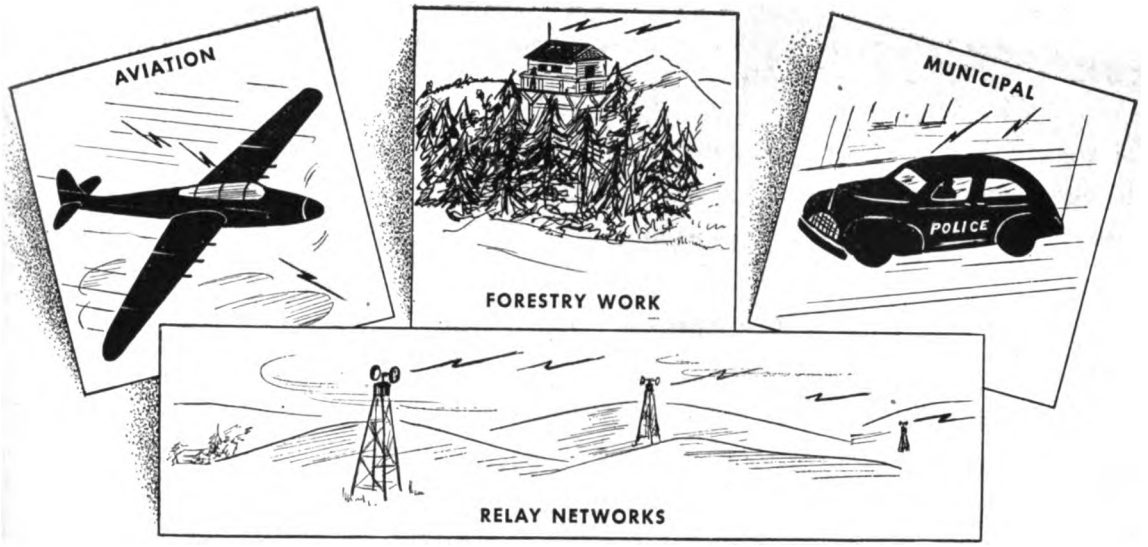

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R. C. Cosgrove explains an outside loop to associates from American and Canadian RMA's at Rye, N. Y. Others are A. B. Oxley, Montreal; R. A. Hackbush, Toronto; R. M. Brophy, president of the Canadian association; Bond Geddes

chester Country Club, Rye, N. Y., the meeting featured a luncheon and a reception at both of which prominent people from the radio industries of the two countries became better acquainted as shown in the accompanying illustrations.

Experimental Radar Licenses

A LIMITED NUMBER of experimental Class 2 licenses will be issued by FCC for compilation of data on operation of navigational radar devices — particularly information which might be useful in formulating regulations governing the operation of radar stations.

Channels have been designated above 25 mc specifically for radio aids to navigation but they are subject to change or modification necessitated by the results of the next World Telecommunications Conference. Applicants are being cautioned against this risk.

New F-M Circuit

COSTS FOR F-M receivers may be brought into line with those for a-m sets as a result of a new circuit revealed by Stuart M. Seeley of RCA Laboratories at a recent New York section meeting of IRE.

Insensitive to electrical interference of all kinds, the new circuit is a ratio detector. Not only is it free of a critical threshold signal level but its use in a receiver eliminates the need for special noise suppression stages which formerly increased costs of f-m receivers without adding anything tangible to their operation.

It was simultaneously announced

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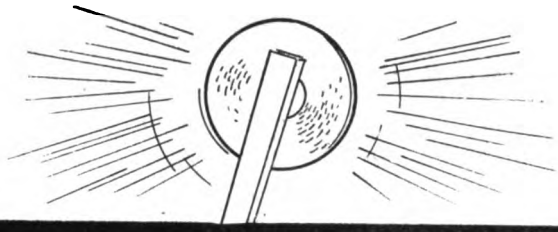

KLIXON Snap-Acting CONTROLS

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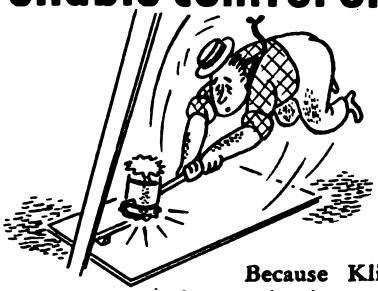

Because Klixon Snap-Acting Controls are simple, and foolproof with *no* complicated operating mechanisms, they always provide accurate control or protection in every application. Small, lightweight, compact, they fit into products without complicated design alterations. They operate surely and dependably even under shock, vibration, motion or altitude.

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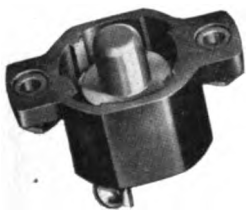
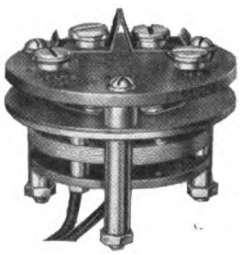


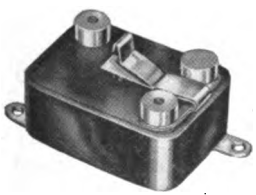
Type PM (NAF-1131) Circuit Breaker.

Type B-3120 Thermostat and Heater, Crystal Dew Point Control.

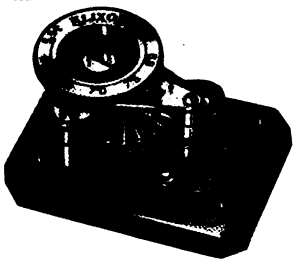
Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.



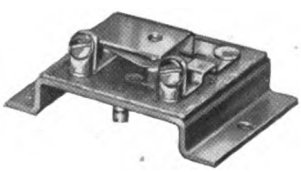
Type ER Series. Ambient Compensated Time Delay Relays.



Type C-7220 Precision Snap Switch 12 amps. 30 Volts D.C., 125 Volts A. C.



Type RT Thermostat. Adjustable Temperature Control.



Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.

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ELECTRONIC ENGINEERS now developing circuits for domestic receivers, or any other devices in which precise frequency-control is essential, will find helpful collaboration here. We are quantity producers of the most difficult crystals, and can meet your specifications as to frequency, quantity and delivery date.

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Control Crystals

by RCA Victor division of RCA t... the development would be embod... in future models of f-m receiv... produced by the company.

Radar Specifications

THREE TYPES of radar are cover... in specification briefs sent by ... U. S. Coast Guard to makers ... electronic gear. The types are des... nated A, B, and C. Class A is t... highest-definition equipment c... able of giving early warning ... approaching vessels and the ... navigational assistance co-ordina... with racon (radar control of n... gation) and identification beac...

Class B will have less resolu... and will operate only with ... identification beacons, while C... C will comprise that equipment w... such low resolution that it can s... only as anti-collision gear.

RMA Divisions

SPEAKER MANUFACTURERS wi... RMA have been transferred f... the amplifier and sound equip... division to the parts division w... a new speaker section has ... established. Its chairman is Ge... R. Haase, Operadio Co. A ... speaker parts section has ... started in the same division ... A. D. Plamondon Jr., Indiana ... Products Co., as chairman.

In the transmitter division ... following section chairmen ... been appointed: transmitter ... section, E. H. Fritschel, Ge... Electric Co., Schenectady; bro... transmitter section, C. W. ... Westinghouse Electric Corp., ... more, reappointed; marine sec... R. E. Samuelson, Hallicrafters ... Chicago; aviation section, F. C. ... Mullen, Western Electric Co., ... York; emergency service comm... cations section, H. F. Mickel, ... Victor Division, Camden, N. ... piezoelectric quartz crystal sec... George E. Wright, Bliley Elec... Co., Erie, Pa., reappointed.

FCC Against Interference

RULES AND REGULATIONS are be... considered for promulgation ... FCC to govern the design and ... eration of gear utilizing r-f en... for non-communication purp... Medical diathermy and indu... heating equipment would be...

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An Announcement

To Our Friends and Customers

After several years of research we are pleased to announce to our many friends and customers the completion of our Selenium rectifier development program.

We are proud to present **Seletron** an extremely highly stable selenium rectifier incorporating a metal alloy in conjunction with aluminum plates.

We are ready to accept orders for units up to 1000 ampere capacity with excellent delivery schedules. Your immediate inquiries for selenium rectifiers are solicited.

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MOTORS and GENERATORS

Type FB units are newly engineered to meet most exacting requirements for fractional horsepower motors and generators. Available as D.C. permanent-magnet generators or motors, D.C. shunt-wound, series-wound or split-field motors. D.C. motors can be wound to operate on voltages from 6 to 115 v. Also available in A.C. types as permanent-magnet generator wound to generate 2-pole single phase, 2 phase or 3 phase; as A.C. series motor with power supply up to 115 v., 60 cycles, single phase; also as universal series motor up to 115 v. Efficiency of motors as high as 45-60% on some applications.

Stainless steel shafts, aluminum die-cast housing finished in baked enamel. Overall dimensions 4" long (exclusive of shaft) by 2½" over flange. Designed for either base or flange mounting. Weight from 26 to 32 oz. according to type.

Complete performance data available on request.

ELECTRIC INDICATOR COMPANY
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primary target because they create serious interference particularly in congested city areas.

The commission has also announced its readiness to test for type approval, diathermy units designed to operate within the three frequency bands set aside for the purpose.

Industry Quadrupled

BECAUSE THE RADIO industry has grown to four times its size before the war it could satisfy the most extensive estimates of consumer demand within a year, believes James J. Nance, vice-president of Zenith Radio Corp. Speaking before the Sales Executives Club in New York recently he put the immediate pressing demand for receivers at 5 million and mentioned a normal replacement demand of 25 to 40 million. Production in the last pre-war year was 14 million.

Snowbound Engineers

ATOP THE 11,485 ft. Mount Gorgonio in Southern California this winter, engineers from Raytheon Mfg. Co. will operate equipment for testing the feasibility of permanent tele and radio relay stations there. Suitable buildings have been erected and the party will hole up for the season, supplied with the necessities of life by packhorse.

Dielectrics at Cedar Rapids

AT A RECENT meeting the Cedar Rapids Section of IRE heard R. F. Field, General Radio Co., present a paper titled, The Behavior of Dielectrics Over Wide Ranges of Frequency, Temperature, and Humidity. Accompanying his talk with slides, Mr. Field outlined the theoretical and mathematical aspects of the subject, and demonstrated that such behavior can be predicted to a first approximation when only a few parameters are known.

While it might be said that raising the temperature increases both dielectric constant and dissipation factor, Mr. Field showed that the correct statement is that increasing the temperature moves the curves bodily up the frequency scale. For any one temperature, a curve plotted against frequency reveals that the inflection point of the curve for dielectric constant occurs at the

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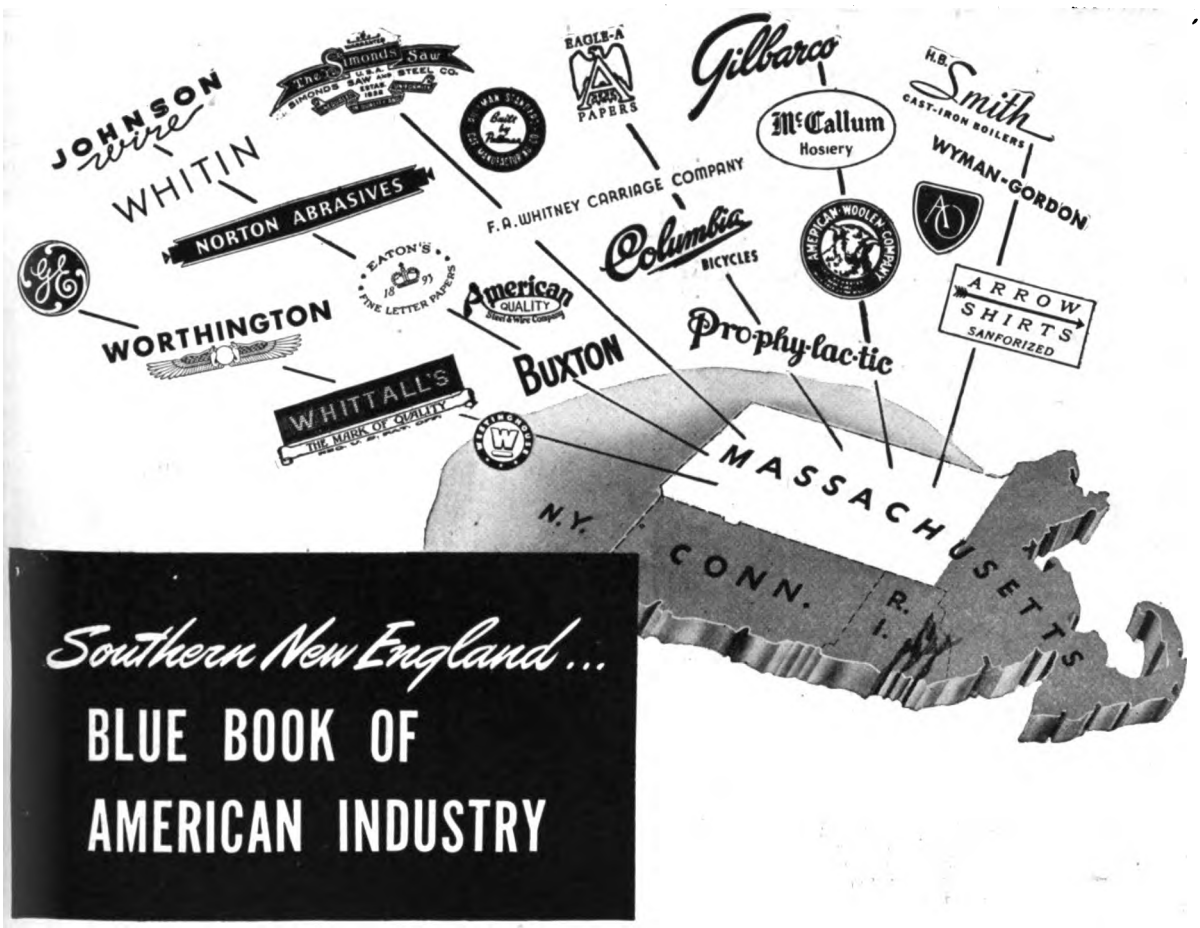

Southern New England...
BLUE BOOK OF AMERICAN INDUSTRY

GET out your directory of manufacturers . . . check with any credit rating service . . . and you'll discover more leading industries with headquarters—or branches—in Southern New England than in any other part of the country.

For example, while you probably associate the name of General Electric with Schenectady, General Electric also has large plants here in Massachusetts. So have Cluett, Peabody; Westinghouse; Pullman.

As for American Optical, Simonds saws, Whitney carriages, American Woolen, Pro-phy-lac-tic brushes, M. J. Whittall rugs, and many more . . . they were native born.

These manufacturers did not pick Southern New England by chance.

They chose Southern New England because it was the most highly-industrialized area in the whole United States . . . and always has been.

Also, because Southern New England is in the heart of the great mass of America's consuming public.

Inside a radius of 500 miles from the center of Southern New England are 58,000,000 people to use Southern New England's consumer goods and her vast output of producer commodities . . . the parts and tools upon which other industries depend to keep going.

And through her great seaports, Southern New England is only a step away from tidewater and easy access to the foreign markets that will develop now that the world is again at peace.

If your postwar plans are still in a state of flux, think hard about Southern New England . . . a great place to promote your new or expanding business . . . and a great place to live and play, too.

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A full-color booklet is yours for the asking: *"Southern New England For Tomorrow's Industry"*. Get your copy by writing to P. E. Benjamin, Manager of Industrial Development, The New Haven Railroad, 80 Federal Street, Boston 10, Massachusetts.

This is one of a series of advertisements presenting the industrial advantages of Southern New England.

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FOR HIGH FIDELITY
IN TONE QUALITY

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• Astatic's increased manufacturing facilities are being taxed to capacity to meet the ever-increasing demand for Astatic Phonograph Pickups. Higher fidelity of recorded sound, made possible by low stylus pressure, offset head, reduced record wear, lower tracking error and other characteristics, make Astatic Phonograph Pickups favorites with a majority of leading manufacturers of phonographs, radio-phonograph combinations, record-changers and play-back equipment.

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ASTATIC Crystal Devices manufactured under Brush Development Co. patents.

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IN CANADA. CANADIAN ASTATIC LTD., TORONTO, ONTARIO

same frequency at which the dissipation factor is a maximum.

A frequency range of sixteen decades will show that more than one such inflection point can occur. Different types of polarization are the explanation for this phenomenon, dipole polarization existing above 1 mc, and interfacial polarization at frequencies below 1 cps.

A plot of dielectric constant vs frequency for different temperatures reveals that there is no single dielectric with a zero temperature coefficient of dielectric constant and that no combination of dielectrics can yield a zero coefficient over a sufficiently extended frequency range. The temperature coefficient is negative at high and low frequencies, positive in the middle region, and zero where the curves cross.

During a recent IRE meeting in Cedar Rapids this group of Navy students from Iowa State College looked on while Collins Radio Co. engineer Donald Jenkins demonstrated a communications transmitter

Placing a dielectric in high humidity causes the formation of an ionized conducting film of water on the surface. The surface resistance quickly drops to only a small fraction of its dry value. If the material is porous, water is absorbed which will maintain the surface film for long periods of time. The lowered insulation resistance increases the dissipation factor of a dielectric inversely with frequency.

In order to take measurements at frequencies in fractions of cycles per second, an indirect method is used which consists of measuring the charging current against time with a steady applied voltage. Such a curve contains the same information as curves of dielectric constant and loss factor vs frequency.

Approximately fifty Navy and ci-

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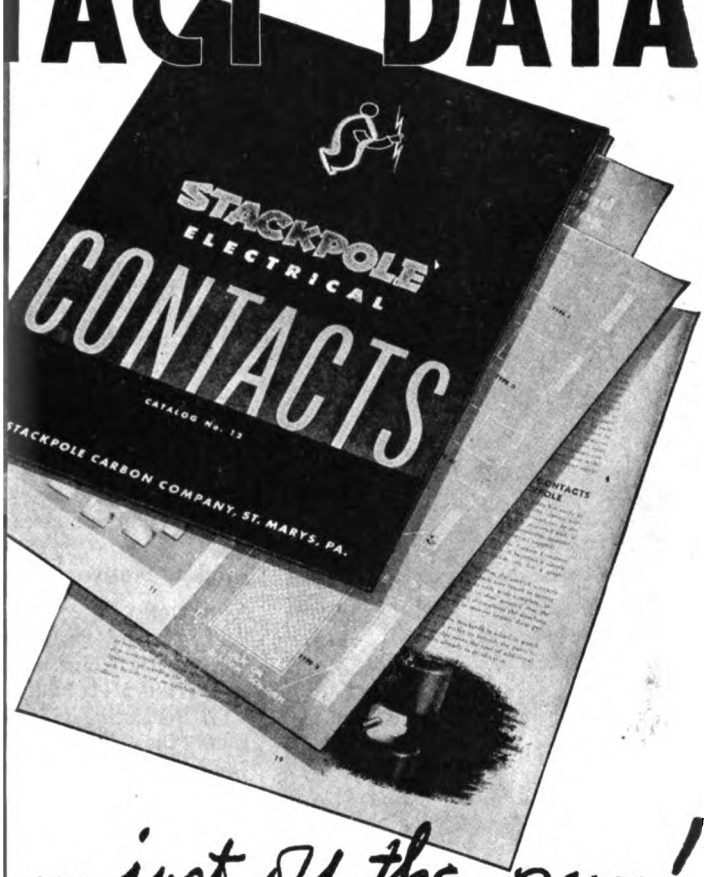
TACT DATA



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If your product uses contacts you'll find in this new Stackpole Contact Catalog a wealth of information designed to help you select units for maximum service under all conditions of use. New contact developments described will prove highly important in the design of smaller, better post-war electrical equipment. Write today!

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vilian students at Iowa State College were guests at the meeting. During the day they were entertained by the Collins Radio Co., with a lunch and a tour of the plant. In small groups they were escorted on the tour by members of the Collins engineering staff who explained and demonstrated various Collins products.

New TBA Members

LATEST AFFILIATED member of TBA (Television Broadcasters Association) is Westinghouse Electric Corp., manufacturing division, Baltimore. C. J. Burnside is the official representative. Syracuse University and Western Reserve University have been added to the association's educational roster. They will be represented respectively by Kenneth Bartlett and Barclay S. Leathem. Yale and Rutgers already belong.

Mickey Network

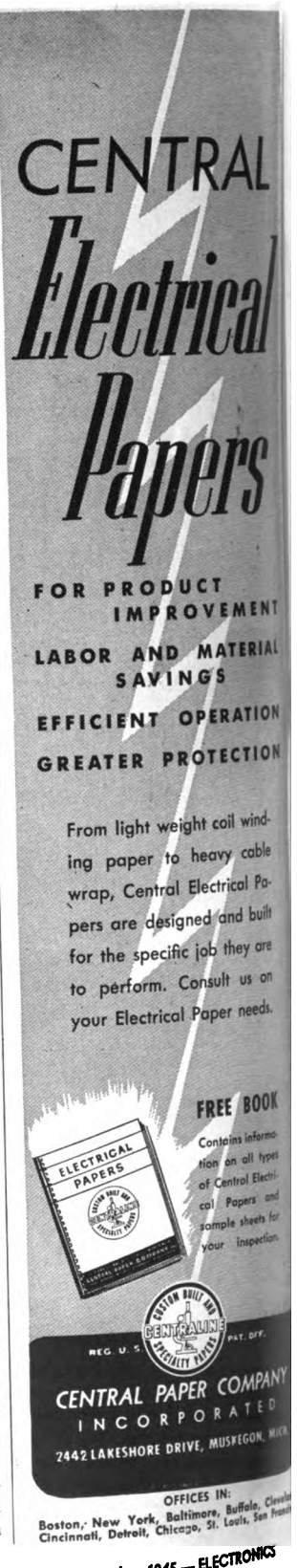
A NATIONWIDE SYSTEM of airway traffic control has been visualized by L. A. DuBridge, executive director of the MIT Radiation Laboratory. Consisting of 200 mickey-type radars the network would cost about $20 million.

Airways traffic controllers would be able under this arrangement to see all the planes in flight in their specified area—a 20- to 30-mile range. In the opinion of Dr. DuBridge, equipment of this type is well past the experimental stage.

Reviewed Wire Recording

DEVELOPMENTS IN WIRE recording were discussed by Hugh Davis of J. P. Seeburg Co. in a paper presented at the first fall meeting of the Chicago Section of the IRE. The subject is divided into three main heads: types of wire, recording heads, and mechanisms.

Round wires of stainless steel having diameters of 0.004 or 0.006 in. are in most common use; however, some recording is being done on flat tapes 0.002 by 0.008 in. In instances where cost is an item plated wires have been tried. Recording in parallel tracks on wide tape has been successful. Tape recordings, wound in pancakes, offer the advantage of indexing which is not possible with recordings on round wires. One German system



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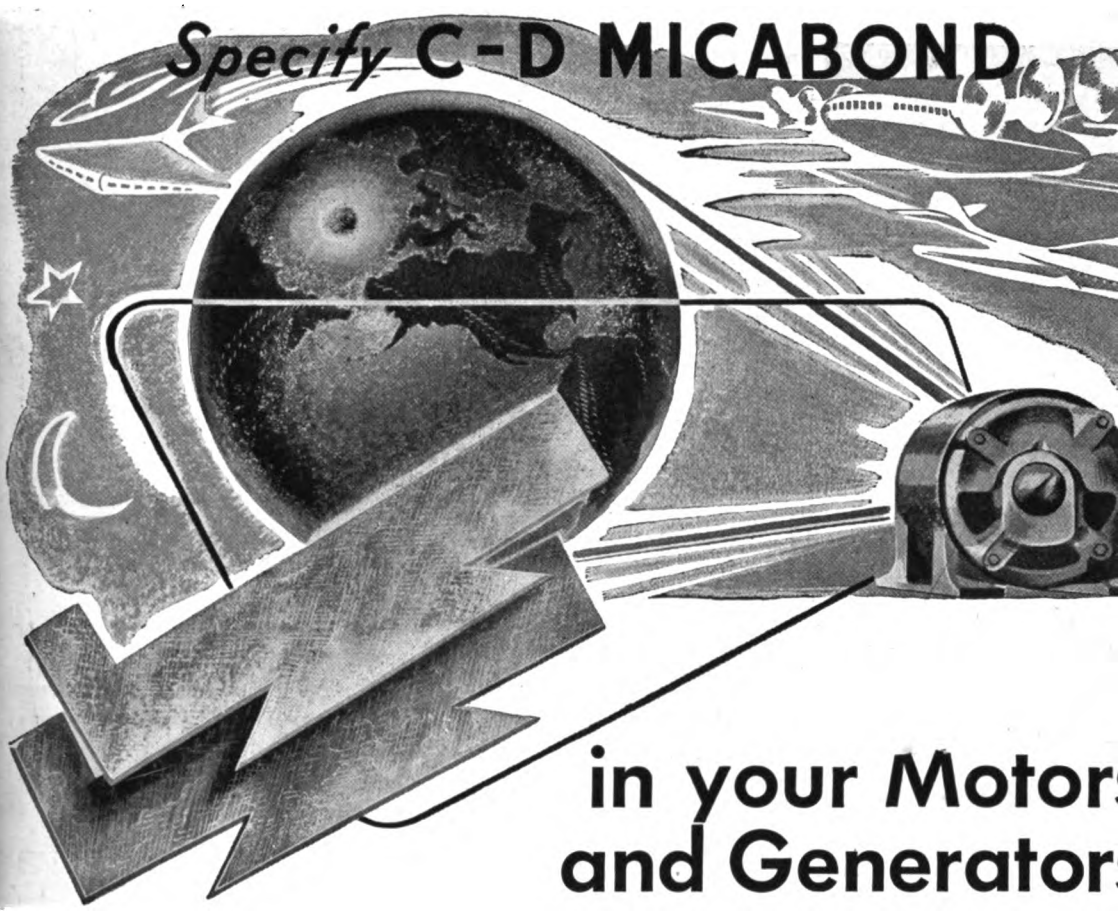

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Generator and Motor manufactur specify C-D MICABOND because provides them with the "perfect insu tion"—MICA—in usable forms. C MICABOND sheets, tubes, rings, s ments and other shapes are provided bonding mica splittings with insulati resins. For complete technical and m chanical data send for Bulletin "M".

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Available in Standard Sheets, Rods and Tubes; and Parts Fabricated, Formed or Molded to Specifications.

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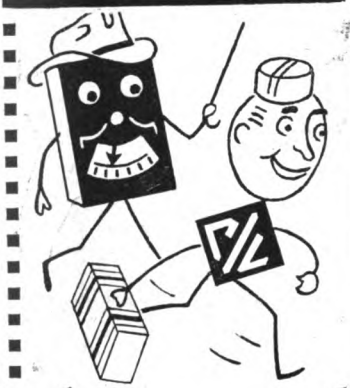

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made recordings on paper tape that had been sprayed with metal. A prime requisite of the wire or tape is that it be uniform.

For ease of loading, open type heads have been almost universally adopted. An improvement in fidelity is obtained by biasing the recording head with a high frequency current, usually about 50 kc. Biasing current is from 0.2 to 0.4 ma. Overbiasing has the effect of reducing the high frequencies and under biasing causes distortion. Erasing is done by increasing the biasing current to 20 ma.

Drive problems encountered are similar to those peculiar to disk recording at 33⅓ rpm. Two feet per second for 0.004-in. round solid wire seems to be the minimum speed for good results. Stretching the wire either in recording or playback will modulate the recorded signal.

Behaviour of dielectrics over a wide range of frequency, temperature and humidity was discussed by Robert R. Field of General Radio.

F-M Receiver Design

ONLY THE 88 TO 108 MC band should be included in new designs of f-m receivers, according to Paul A. Porter, chairman of FCC. Writing to R. C. Cosgrove, president of RMA, Mr. Porter indicated that postwar f-m receivers should not be burdened with the cost of tuning provisions in the 42 to 50 mc bands.

As he pointed out, receivers built to a duplex design might very well retard the changeover from old to

Closeup shows scale and conformation of Geiger-Muller tubes of α type made by North American Philips Co., Mount Vernon, N. Y. Units like these have been in the news recently as the testing elements of equipment used to check radiation at the craters of atom bomb explosions in New Mexico and Japan

For prompt shipments of 3" Cathode Ray Tube Shields, specify "from Metallic Arts Company" when requisitioning from your purchasing department.

MACO SHIELDS

have met the rugged tests of wartime uses . . . they're scientifically designed to do the job expected of them. Adapted for mounting directly on the panel. Functionally designed . . . easy to install . . . sure in operation. These 3-inch shields are made for the 3BP-1 Cathode Ray Tube.

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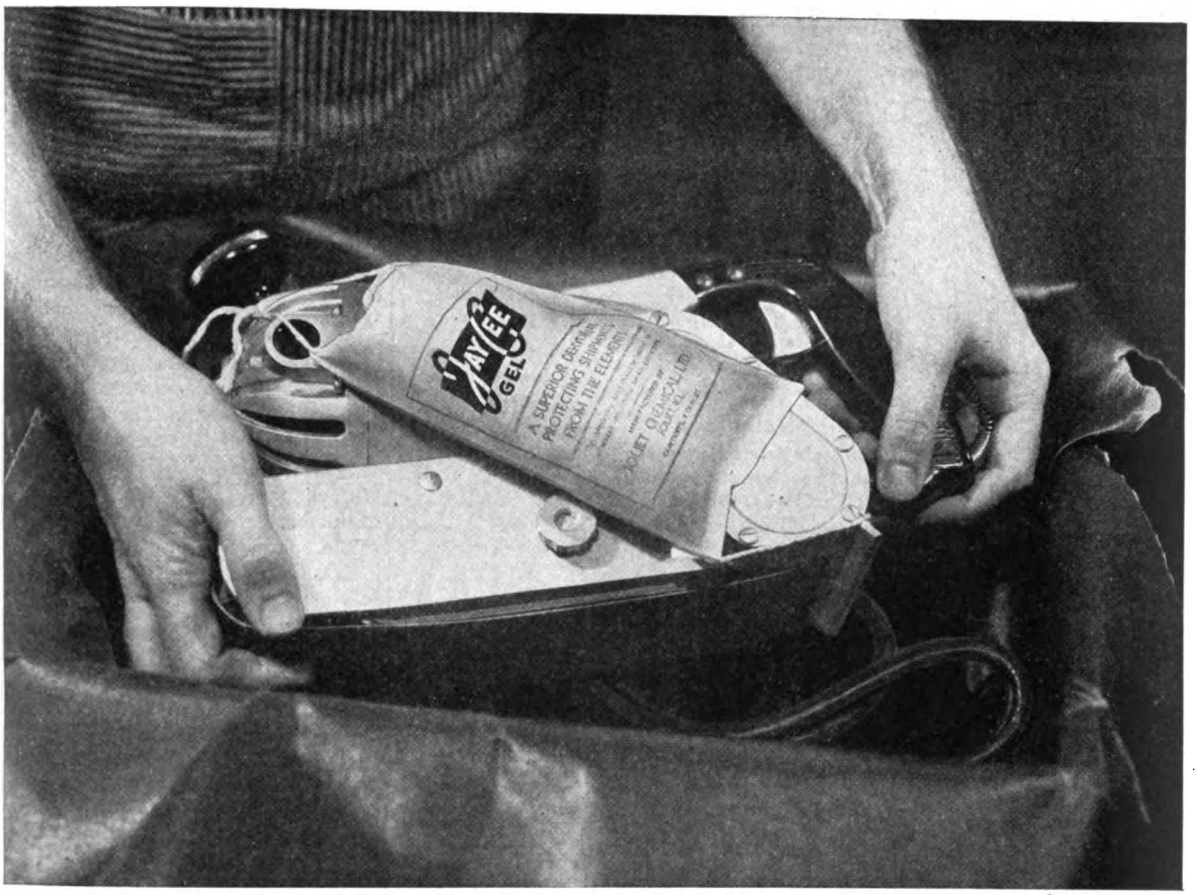

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Moisture "in-the-package" causes vast damage to precision equipment.

Skilsaw, Inc. prevents this damage by means of Jay Cee Silica Gel, the ideal drying agent. A few small bags of the Jay Cee Gel are included within tightly sealed packages of electric handsaws, drills, and other tools. The gel has amazing power to absorb and hold moisture. Thus the air in the package is kept thoroughly dry and damage from rust or corrosion is avoided.

This practice is being followed by more and more manufacturers of metal products. The cost of the gel is a mere trifle in comparison with the possible damage from rust or corrosion.

Jay Cee Silica Gel has wide application in the Air Conditioning, Refrigeration, and Chemical industries. It is clear white; passes a rigid section test; meets exacting Government specifications; is strictly a quality product.

A few excellent Jay Cee Silica Gel sales territories are still open to jobbers. Write for details.

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new band. The objective of FCC in allowing f-m stations to continue operation in the lower band was to prevent the loss of service to listeners who have not been able to convert or replace their receivers.

Conditional F-M Grants

BECAUSE MEN in the military service are confronted with particular difficulties in completing applications for broadcast facilities, FCC reminds that it has proposed to make conditional grants of f-m applications, affording the applicants a period of 90 days in which to file engineering details. However, since f-m channels cannot be reserved for future assignments, promptest possible submission of applications is advocated.

License Transfer

PUBLIC INTEREST underlies a new plan suggested by FCC for the transfer of licenses from one broadcaster to another. Under the plan the Commission and the seller would publish the terms and conditions of the proposed sale of broadcast facilities and the name of the prospective buyer who has met the seller's price. Other persons desiring to apply for the station would be invited to do so on the same terms and conditions. The Commission would consider all applications on their merits with a view to granting the transfer on the basis of public interest.

Another suggestion designed to improve FCC's transfer procedure will be recommended to Congress. This will be a yardstick for measuring the appropriate value of a station so the Commission's field of choice will not be unreasonably restricted because of sales of stations at artificially high prices.

MEETINGS TO COME

DEC. 12; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Mathematical Formulations for Linear Servomechanism Systems, by Charles F. Rehberg, New York University; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

JAN. 9; AMERICAN INSTITUTE OF

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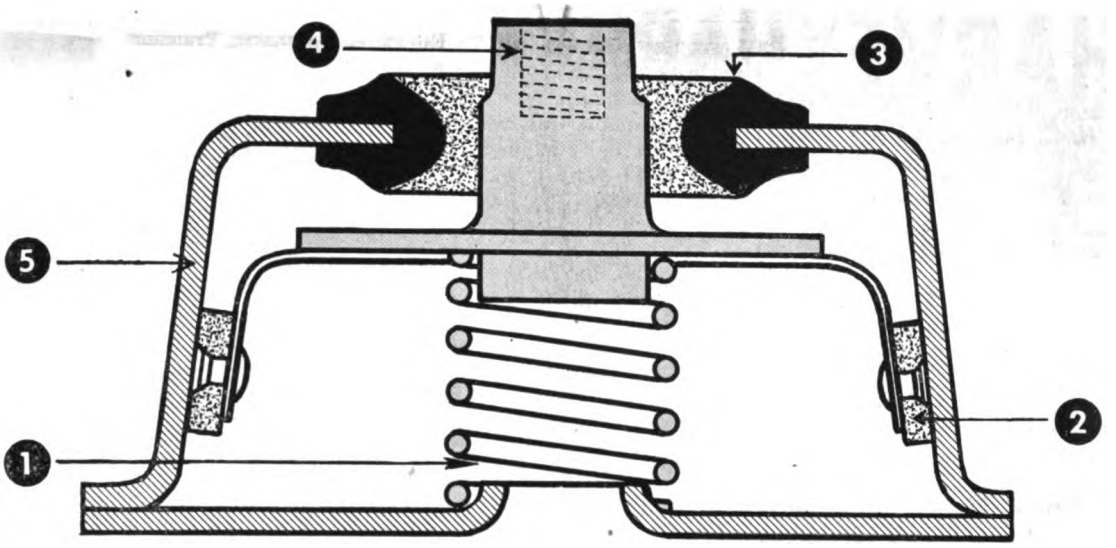

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Robinson engineers offer a low-cost standardized Vibrashock unit mount that closely approaches the high operating efficiency of the famous custom-built Vibrashock Dual Suspension.

Without sacrificing the proven basic Robinson principle of three-way vibration absorption, the new unit mounts are simple, rugged and long-lived. Comparative tests show marked improvement in performance over conventional type unit mounts.

The use of stainless steel springs, instead of rubber or synthetic, eliminates drift or permanent set and vulnerability to cold, heat or humidity.

Check your equipment—airborne, vehicular, mechanical — on these triple action mounts. The results are startling. (On one such application, electronic tube life has been increased from ten days to ten months.)

Vibrashock unit mounts are available in three sizes, and in a wide range of load ratings. Designers, engineers and purchasing agents will find in our new catalog "Vibration Control Engineered by Robinson," the answer to most vibration problems. Send for your copy of this new publication today.

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CHECK THESE OUTSTANDING FEATURES OF THE VIBRASHOCK UNIT MOUNT

1. Stainless steel spring provides complete three-way freedom in a ***single unit.*** (Conventional units are resilient in only one direction and must be assembled in tandem for horizontal absorption, requiring twice the normal quantity of mounts.)
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This combination of features assures outstanding performance in the first *complete* unit mount offered to Industry.

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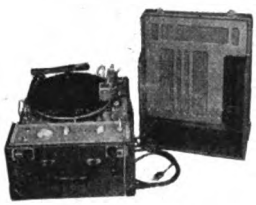

A portable sound recorder, record player and public address system. Complete in a single carrying case.

The Model "K" records 15 minutes continuously at 33⅓ RPM on side of 13¼" disc. It also makes 6, 8, 10, and 12 inch records, and plays all makes of phonograph records. With its many exclusive features found in no other low priced recorder, the user is able to make high quality recordings consistently, reducing spoilage cost of discs and needles. As a voice amplifying system, it serves audiences of about 500 persons.

PRESTO *Model "L"*
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For those who demand "something better" in portable reproducing equipment. Small, light weight, easy to operate.

Its extreme simplicity and remarkably clear, wide range reproduction have made the Model "L" a favorite of radio stations, advertising agencies and program producers. It consists of a 12" dual speed rim-driven recording turntable, a 16" pickup on a swivel mounting which folds into the case when not in use, a 4½ watt amplifier and an 8" loudspeaker, mounted in a single case. The speaker mounted in the case cover is equipped with a 20' extension cable. Semi-permanent needle supplied as initial equipment.

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ELECTRICAL ENGINEERS; Transient Analysis of Linear Servomechanisms, by John R. Ragazzini, professor, Columbia University; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St, New York 18, N. Y.

JAN. 18-FEB. 7; GARDNER DISPLAY CO., Products of Tomorrow Exposition; Coliseum Group, Chicago, Ill. Marcus Hinson, general manager planning department, Armory, 16th and Michigan, Chicago.

JAN. 23-26; INSTITUTE OF RADIO ENGINEERS, 33d Annual Winter Technical Meeting; Astor Hotel, New York, N. Y.; E. J. Content, chairman of meeting committee, WOR, 1440 Broadway, New York 18, N. Y.

FEB. 4-7; AMERICAN WELDING SOCIETY, National Meeting; Hotel Cleveland, Cleveland, Ohio; M. M. Kelly, secretary, 33 West 39 St., New York 18, N. Y.

FEB. 4-8; AMERICAN SOCIETY FOR METALS, National Metal Exposition; Public Auditorium, Cleveland, Ohio; W. H. Eisenman, secretary, 7301 Euclid Ave, Cleveland 3, Ohio.

FEB. 6-8; AMERICAN INDUSTRIAL RADIUM & X-RAY SOCIETY, Annual Convention; Hollenden Hotel, Cleveland, Ohio.

FEB. 13; AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS; Frequency Spectrum Theory Applied to Servomechanisms, by E. B. Ferrell, Bell Telephone Laboratories; Room 301, Pupin Hall, Columbia University; H. E. Farrer, AIEE Headquarters, 33 West 39 St., New York 18, N. Y.

FEB. 25-MAR. 2; INTERNATIONAL EXPOSITION CO., 20th Exposition of Chemical Industries; Grand Central Palace, New York; Charles F. Roth, manager, Grand Central Palace, New York 17, N. Y.

FCC ACTS

To permit:	To do this:
U-Dryvit Auto Rental Co. Boston, Mass.	Install three portable and portable-mobile stations in vehicles to establish cost of service in use of rented radio-equipped trucks. Federal Telephone & Radio Corp. gear will be used on f-m at 50 w. Frequencies will be assigned.
RCA	Construct and operate four new experimental Class 2 portable radio

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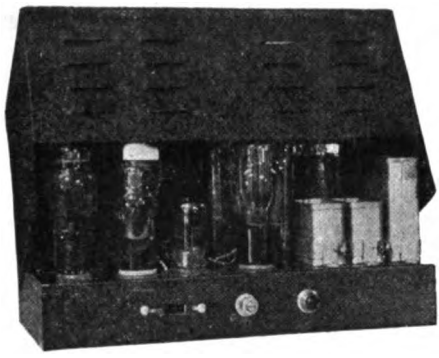
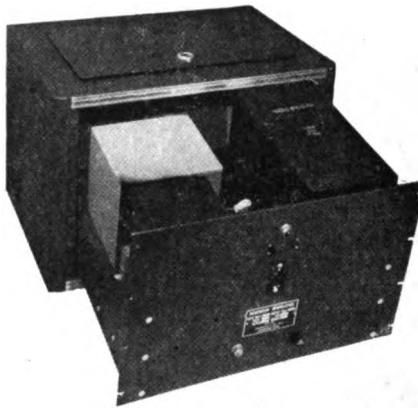
ELECTRONIC A.C. VOLTAGE REGULATOR



Model 250



Model 1750

AVAILABLE FOR IMMEDIATE DELIVERY

Model No.	Load Range
250	25 to 250 V.A.
1000	200 to 1000 V.A.
1750	800 to 2000 V.A.
5000	1000 to 5000 V.A.

NOTE THESE FEATURES:

- Output voltage maintained to within ± .2% (adjustable 110-120 volts) with input fluctuations 95 to 130
- Output voltage constant to .2% despite variations in load over entire rated range of unit
- Minimum wave form distortion—about 5% average
- Independent of load power factor
- Independent of frequency variations ± 15%
- Quick response time—output voltage stabilized in SIX cycles maximum
- Built for long, trouble free service. Component parts conservatively rated—transformers, etc. hermetically sealed

For additional information and prices, write the factory or our Sales Representative nearest to you.

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BURLINGAME ASSOCIATES, LTD.
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NEW YORK CITY

Middle West
ALFRED CROSSLEY ASSOCIATES
549 WEST RANDOLPH STREET
CHICAGO, ILLINOIS

West Coast
N. B. NEELEY ENTERPRISES
7422 MELROSE AVE.
HOLLYWOOD, CALIF.

SORENSEN & COMPANY, INC

AIRBORNE ELECTRONICS

STAMFORD,

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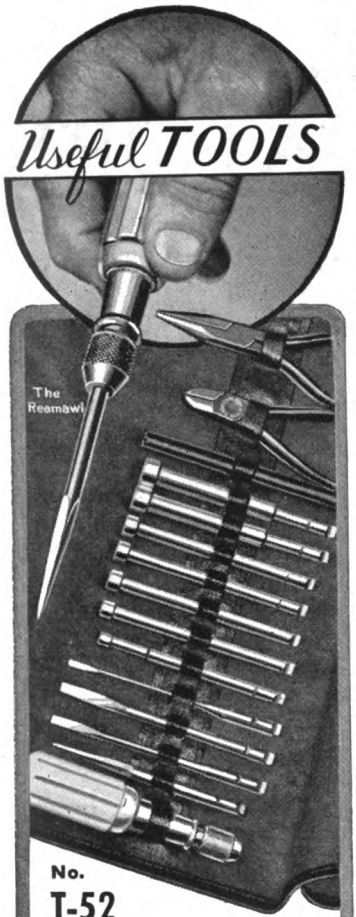

No.
T-52
SPINTITE SET.
Chuck Type Handle with Reamawl, 3 Screw Drivers, 7 SPINTITES, Insulated Neutralizing Alignment Wrench, and 2 Pliers, all in a Leatherette Roll. . . .
A Positive need in every RADIO, HOME and ELECTRICAL SHOP.
A Fascinating, Fast-Moving Item for thousands of stores.
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	stations for testing a system of wide-band multi-channel radio communication between Philadelphia or Camden, N. J. and New York City with intermediate relay stations to be located in Bordentown, N. J. and Tenmile Rum, N. J. Frequencies will be assigned; power 1 w, and emission, A0, A1, A2, A3, A4 and Special.
University of Chicago Chicago, Ill.	Install a new experimental portable mobile radio station aboard a free balloon for operation within a 350-mile radius of Chicago. Objective is to transmit information on the nature of penetrating radiations in the stratosphere. Transmitters will be frequency modulated by impulses produced as a result of high-energy particles passing through a set of coincidence-counter tubes in a cosmic ray telescope. Frequencies will be assigned; power, 2 w; and emission special for radiosonde purposes.
Tanner Motor Livery, Ltd. Pasadena, Calif.	Temporarily operate one experimental Class 2 land station and two portable mobile stations in taxicabs. Frequencies will be assigned; power, 30 w; emissions A1, A2 and A3.
WIBU Poynette, Wis. AT&T	Install new vertical antenna and change ground system. Install an additional 339-mile link in the proposed New York to Los Angeles coaxial cable extending from Meridian, Miss. to Shreveport, La. at a cost of $7,056,000.

BUSINESS NEWS

AMERICAN PHENOLIC CORP. in Chicago is erecting a three-story building to house their expanding manufacture of plastic items for the electronic trade and other industries.

AIREON MFG. CORP. paid $400,000 for 100 percent of the stock in Oxford-Tartak Co. and Cinaudagraph Corp., Chicago, Ill.

WILMOTTE LABORATORIES opens a branch laboratory at 236 W 65 St., New York 19, to provide complete engineering service in the application of electronics for industrial uses.

UTAH RADIO PRODUCTS CO., Chicago, and Universal Cooler Corp., Marion, Ohio, have merged into International Detrola Corp. The merger unites companies with a total of nine manufacturing plants in this country and two in Canada, making home and auto radio receivers, loudspeakers, other radio parts, refrigerators and furniture cabinets.

THE MUTER CO. of Chicago has acquired all capital stock of the Rola Co. in Cleveland. Larry King, formerly with Operadio, will be president and general manager of the Rola Co., to be operated as a division of the Muter Co. Ben Engholm,

QUALITY PLASTIC PARTS

PRECISION-MADE TO YOUR EXACT SPECIFICATIONS

Here is a dependable source for quality special parts or products fabricated from plastic sheets, tubes and rods. No matter how complicated your requirements may be, you can count on Sillcocks-Miller specialists to deliver accurate work to meet your most exacting specifications. You'll find it costs you less to pay a little more for Sillcocks-Miller quality.

Write for illustrated Booklet describing helpful 4-way service

THE SILLCOCKS-MILLER CO.
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Specialists in High Quality, Precision-Made Plastics Fabricated for Commercial, Technical and Industrial Requirements

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Good News for Research Men

Research Departments of some of America's great industries have called upon Jerome Engineering Company to develop specialized photographic equipment. We are prepared to offer this same service in Design, Development and Production to your Engineering problems. Here illustrated are some of the units which we wish to present in present or modified form. These are:

(1) **Automatic Impulse Camera,** 35 and 70 mm. for Electronic Research. Has many uses.

(2) **Automatic Photographic Processing Machine.**

(3) **Microfilm Filing Camera,** for reducing diagrams, drawings, and engineering data to a card filing system.

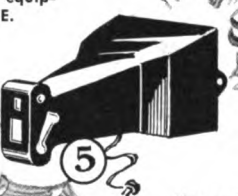
(4) **Portable Recording Camera** for removable instrument panels.

(5) **Low-Priced Copy Camera,** for engineering data and sketches. Takes copy up to 10" x 14". Has own built-in illumination.

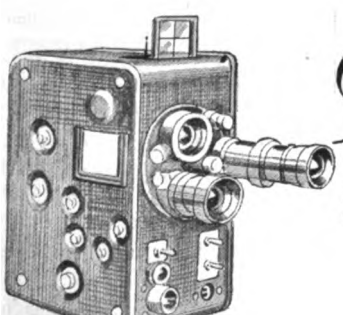
(6) **Universal Projector,** for motion picture and still projection. Has remote control and viewing or editing screen.

(7) **Oscilloscope Camera,** for recording oscilloscope traces, etc.

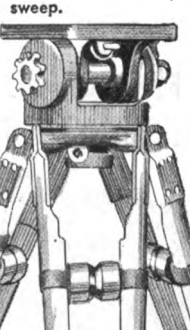
In photographic research and design, experience counts as in other branches of engineering. If you have need for specialized photographic equipment—HAVE IT ENGINEERED BY JEROME.



35 mm. Automatic Data Recording Interval Still and Motion Picture Camera, for time-lapse photography.



Heavy-Duty Professional Tripod — Built-in Heater for low-temperature work, if desired. Fast and controlled slow panoramic and elevation sweep.



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MERRICK & HICKSVILLE RDS.
PHONE. MASSAPEQUA 2100

Long Island N.Y.

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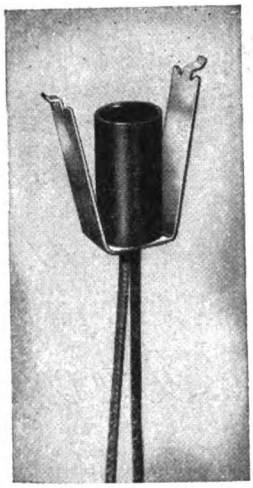
Specify DRAKE for Better Dial Light Assemblies

THE Dial Light Assembly of the number 500 U Series illustrated here, is one of the outstanding units of the widely known DRAKE No. 500 Series. The legs of the bracket are made in various lengths, from 27/32" to 1-7/16" from base to shoulder. This unit will fasten on any panel from 0 to .062 thick. When specifying Dial Light Assemblies, remember millions of DRAKE 500's have been used *since 1940!* These units are TIME-TESTED . . . offer you all the superior advantages developed through years of highly specialized experience in designing and manufacturing Dial and Jewel Light Assemblies *exclusively*. Extensive facilities for high speed production bring you better quality at low cost. Is the newest catalog listing the complete DRAKE line at your finger tips, NOW?



No. 542 U-43 . . . the unit shown above, has 1-5/16" legs built for .043 panel. Prompt shipments assured in large quantities for your production line requirements.

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SOCKET AND JEWEL LIGHT ASSEMBLIES

DRAKE MANUFACTURING CO.

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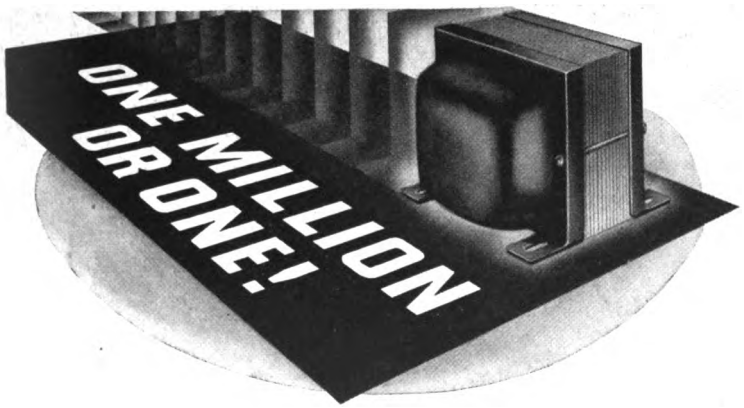

Electronic Engineering can supply—NOW—transformers in standard or special styles in *Any* quantity . . .

ELECTRONIC Engineering COMPANY

SPECIALIZED Transformer ENGINEERS

Because there have been no conversion problems at Electronic Engineering, we are now producing and delivering the *finest* transformers with the same speed and skill as during the war. We are ready to serve your needs . . . with one million or one!

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former president and principal stockholder of Rola, will remain in a consulting capacity.

WESTERN ELECTRIC CO. has purchased a 40-acre tract in Allentown, Pa., for a new electronic components plant that will provide employment for about 1,500 people. Present plans call for production of vacuum tubes, quartz crystals, temperature-sensitive devices, and other precision products for use in the Bell system and in other commercial applications. The manufacturing areas will be fully air conditioned.

HOFFMAN RADIO CORP., Los Angeles, has formed a new CAA Division that will develop material built to specifications of the Authority. In charge will be Elmer P. Gertsch, formerly manager of the Radio Division for Air Associates, Inc.

GILFILLAN BROS. INC., West Coast manufacturer and co-developer with MIT of the famed GCA (described in the Nov. 1945 ELECTRONICS, page 112) staged the first public demonstration, at Los Angeles Municipal Airport, of this radar system for

Lt. Col. Harry Downing, commanding officer, Mines Field, California, and S. W. Gilfillan, president of Gilfillan Bros. Inc., standing before the trailers housing the military version of GCA. The rotating radar antenna is mounted in the curved housing atop the trailer

guiding planes to safe landings through storm, fog and darkness. Gilfillan is now entering full-scale manufacture of GCA equipment as converted to civil uses for landing fields.

SENTINEL RADIO CORP. has broken ground for a modern plant at a location in Evanston, Ill., occupying over nine acres. It will have an estimated production capacity of 3,000 radio sets per day on a single-

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HERE is a significant fact for electronic engineers: No other material can withstand extremely high temperatures like graphite. In fact, graphite *has no* melting point! This means that anodes made of graphite will retain their shape better—will not fuse or warp or melt—no matter how high the manufacturing or operating temperatures.

"National" graphite anodes, because of their higher thermal emissivity, will operate at lower temperature for a given amount of energy dissipated. Result: a lower operating temperature for all tube parts and therefore less distortion and more uniform tube characteristics.

Moreover, "National" graphite used in making anodes has much greater strength, finer grain structure, smoother machined or machinable surfaces, and greatly increased erosion resistance.

Why not investigate further the promising possibilities in using graphite for your anodes? National Carbon Company, Inc., a pioneer in developing carbon and graphite products, looks forward to the opportunity to work with you.

The word "National" is a registered trade-mark of National Carbon Company, Inc.

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Division Sales Offices: Atlanta, Chicago, Dallas, Kansas City, New York, Pittsburgh, San Francisco

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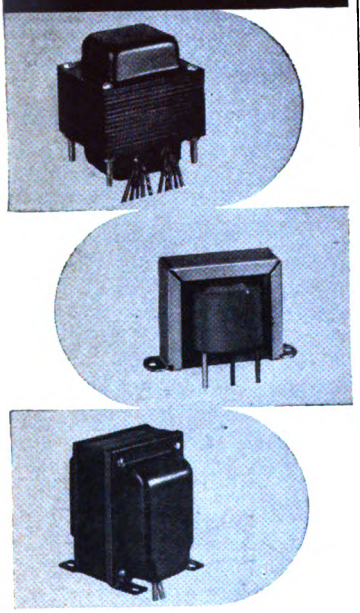
HUDSON AMERICAN TRANSFORMERS



FOR GENERAL ELECTRONIC AND RADIO APPLICATIONS

HUDSON AMERICAN'S 20 years engineering experience has developed *6 outstanding points* of perfection in the manufacture of high quality Transformers:

1. Most modern coil producing machinery available.
2. Vacuum impregnating equipment for wax or varnish.
3. Completely automatic production test equipment.
4. Precise winding and meticulous assembly.
5. Thorough impregnation and careful finishing.
6. Maximum uniformity.

Specify HUDSON AMERICAN TRANSFORMERS for your radio and electronic requirements.

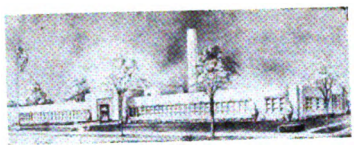
Write for catalog 1045

HUDSON AMERICAN CORPORATION

A subsidiary of Reeves-Ely Laboratories, Inc.

25 WEST 43rd STREET, NEW YORK 18, N. Y.

shift schedule. Production lines 300 ft long will be fed direct from the receiving department at the west end of the building and will turn



Architects' sketch of new Sentinel plant

out completely tested radio sets packed and ready for shipment at the east end of the building.

COMMUNICATION PARTS recently purchased a new plant in Chicago having unique features. Each work bench is an illuminated and wired unit in itself yet all benches can be linked together in a few minutes for a line assembly operation.

WAVEGUIDE ELECTRONICS, 30 Church St., New York, is an organization of men who have been installing radio and radar gear on Navy vessels. The new company has facilities for fabrication and installation of waveguides and coaxial transmission lines, and plans to concentrate on installation and servicing of electronic radio and radar equipment on ships, in plants, at airports, etc.

SYLVANIA ELECTRIC PRODUCTS INC. produced more than 140 million tiny tubes and millions of fuzes for the Navy's secret VT proximity fuze program, also known as "Project A". The eight plants engaged in this work received 22 special awards from the Navy Bureau of Ordnance for efficient production.

PERSONNEL

WM. D. MACGEORGE, formerly chief of the Electronics Laboratory at Baldwin-Southwark, joins the staff of Automatic Temperature Control Co. in Philadelphia as technical consultant concerned with development of automatic control instruments.

J. WESLEY KOCH, until recently a captain with the office of the Chief Signal Officer in Baltimore, is now on the engineering staff of Mutual Broadcasting System. While in the Army, he served as technical adviser of the Radio Propagation Unit and as staff radio officer in North Africa and Italy.

EARL MINOR JOHNSON, radio propagation specialist with the War De-

EVERYTHING IN RADIO AND ELECTRONICS

R. W. T., world's oldest and largest Radio Supply House is ready again with tremendous stocks of sets, parts and equipment. You can depend on our quarter-century reputation for quality, sound values and super-speed service. Orders shipped out same day received. All standard lines already here or on the way, including: National, Hammarlund, R. C. A., Hallicrafters, Bud, Cardwell, Bliley and all the others you know so well.

Originators and Marketers of the Famous Lafayette

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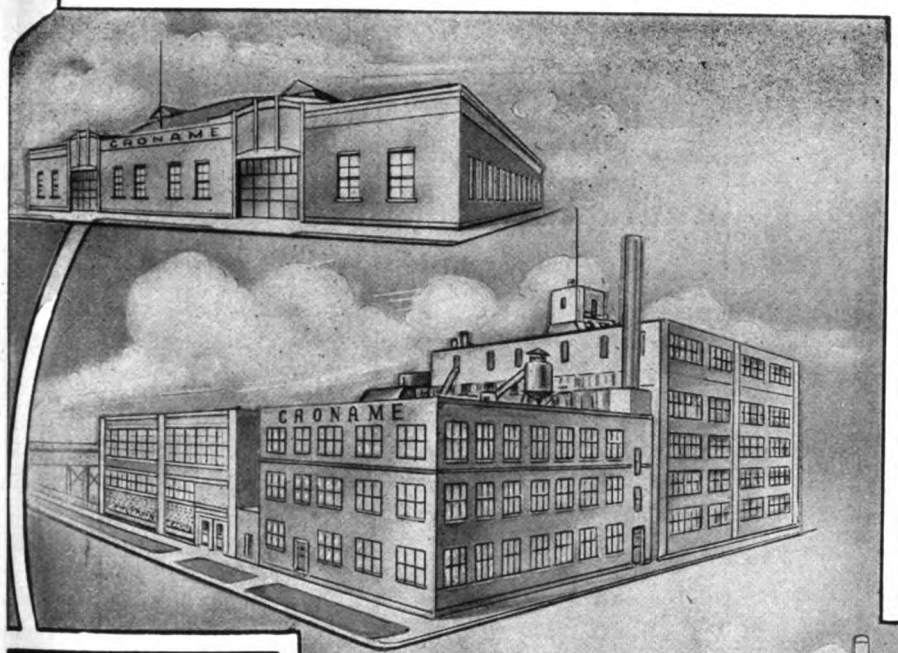
FOR ELECTRONIC COMPONENTS AND FINE METALCRAFT



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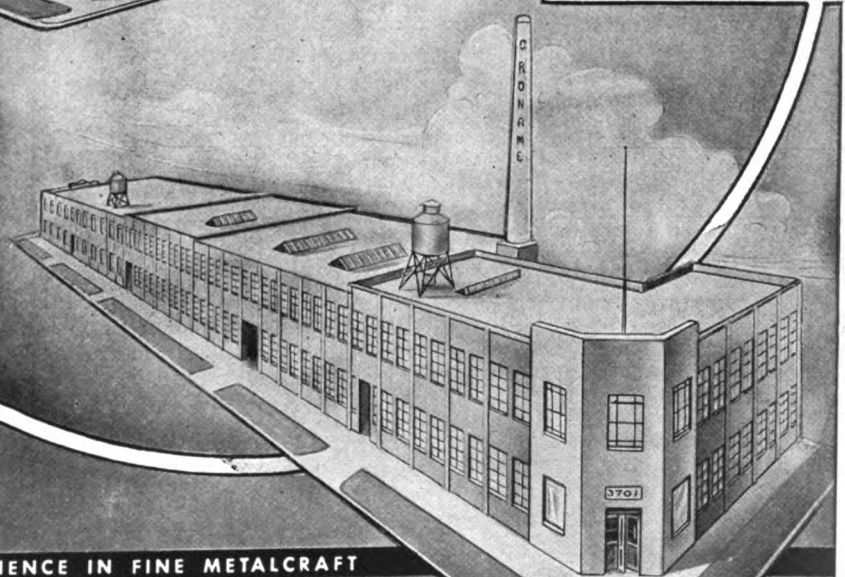
DECORATED GLASS
GLASS DIALS
DECORATED PLASTICS
FORMED PLASTICS
RADIO TUNING UNITS
REMOTE CONTROLS



OVER 40 YEARS EXPERIENCE IN FINE METALCRAFT

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Actual *Size*

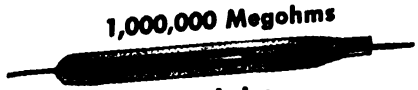
-Series VW-
15 ma., 1.5 volts

Grid current less than 10^{-14} amperes—grid resistance approximately 10^{16} ohms.
Individually checked for uniformity within the range of the best operating characteristics—each tube is built for exacting circuit requirements.

Available as...
Electrometers
Pentodes
Tetrodes
Triodes
Diodes

And now in production —new hi-meg vacuum sealed resistors in a range never adequately covered before—values from 1 megohm to 1,000,000 megohms. Write for literature on tubes and resistors or consult us on your tube problems.

1,000,000 Megohms



Actual size

THE VICTOREEN INSTRUMENT CO.
5806 HOUGH AVENUE
CLEVELAND 3, OHIO

partment since June 1944, is now in the engineering department of Mutual Broadcasting System.

CLURE H. OWEN is allocations engineer with American Broadcasting Co., after serving with the FCC as assistant chief of their broadcast engineering division.

HENRY GROSSMAN, CBS director of technical operations, and JAMES SEWARD, director of operations, are now responsible for technical operations of CBS Television in addition

Henry Grossman

to their regular network broadcast duties. Dr. P. C. Goldmark continues his responsibility for equipment design and installation, engineering standards, and tests.

LOUIS G. PACENT, JR. becomes manager of production services department of Emerson Radio and Phonograph Corp., after a year of service as chief industrial engineer.

T. WANG and T. Y. WANG, representatives of the Chinese Government Communications Commission, interviewed Dr. Ray H. Manson, president of Stromberg-Carlson, during their nationwide tour of key communications centers in search of manufacturing methods and techniques applicable to China's industrial empire.

ERNEST A. MARX, who held the rank of Lieut. Commander in the Navy and the post of Senior Radar Officer of the Third Naval District, joined Allen B. DuMont Laboratories as general manager of their newly formed Television Division.

W. G. H. FINCH, Captain USNR, returns to inactive duty and assumes the presidency of Finch Telecommunications Inc., Passaic,

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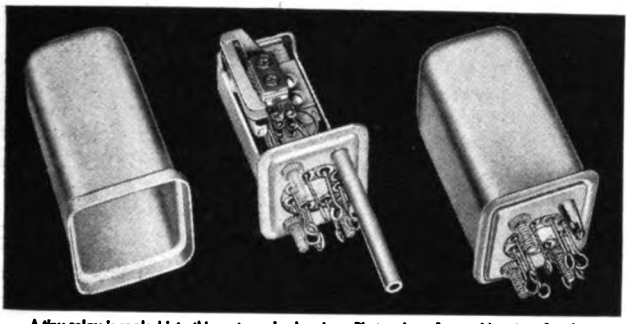
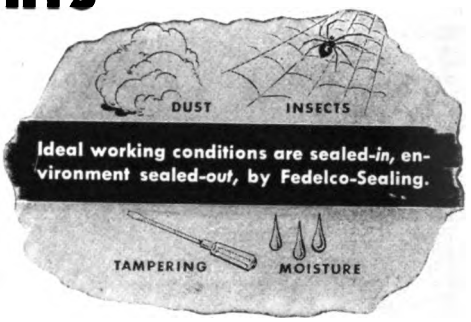
These environment-free products show how *Fedelco-Sealing* can meet Your requirements



A tiny relay is sealed into this rectangular housing. Photos show 1, metal housing; 2, relay mounted on heavy bracket and base, with tube for exhausting air; 3, completed enclosure, with three 6-32 mounting screws and terminals for soldering on No. 14 stranded wire. Tube has been sealed off.



Fedelco-Sealing insures the long life and unfailing per formance built into your product, by sealing it into a air tight metal housing that keeps out bugs, dust, fun gus, moisture, and tampering.

Larger relay, with specially designed anchor plate mounting to withstand shock and vibration up to 20Gs. Relay is bolted to heavy bracket and anchor plate (top left) and base plate. Completed enclosure (right) shows beads rolled into top and bottom of housing to grip both plates, and square base for bolting to frame. Lead wires have been soldered to octal plug.

Designed for Your Requirements

These enclosures are designed and engineered to fit you product and your specific requirements. Cases can be o any required shape, with various provisions for mount ing. Terminals can be wired to an octal plug, or to sol der terminals. Interior mounting and brackets are spe cially designed. Cases are exhausted and filled with nitrogen or other gas. Enclosures can be designed t withstand shock and vibration of any degree specified

We Fedelco-Seal your product, or show you how to do it

Ship your product to us, and we will design the enclo sures, and complete the Fedelco-Sealing job. Or, if your quantities justify, you can do your own Fedelco-Seal ing, with equipment we will design for you.

Three other specially designed enclosures. 1. Oblong case for a large relay, with leads for soldering connection. Mounting sockets in base for 8-32 machine screws. 2. Rectangular case for aviation type transformer, specially designed to fit same mounting as transformer had before moisture trouble made Fedelco-Sealing necessary. 3. Small relay, arranged for plug-in.

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Send us a sample, describe your requirements and prob lem, and we will give you complete and specific infor mation. Write or phone us today.

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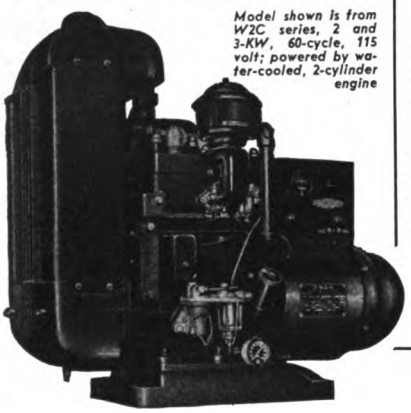
★ ONAN ELECTRIC GENERATING PLANTS supply reliable, economical electric service for electronics applications as well as for scores of general uses.

Driven by Onan-built, 4-cycle gasoline engines, these power units are of single-unit, compact design and sturdy construction. Suitable for mobile, stationary or emergency service.



Model shown is from W2C series, 2 and 3-KW, 60-cycle, 115 volt; powered by water-cooled, 2-cylinder engine

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POWER AND LIGHT FOR EVERY NEED

"Models range from 350 to 35,000 watts. A.C. types from 115 to 660 volts; 50, 60, 180 cycles, single or three-phase; 400, 500, and 800 cycle, single phase; also special frequencies.

D. C. types range from 6 to 4000 volts.

Dual voltage types available.

Write for engineering assistance or detailed literature".

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HIGHER Q:
New formulae make possible higher Q at all frequencies.

PERMEABILITY:
Accurate powder control results in uniform density and higher permeability.

FREQUENCIES:
Q and permeability exactly as specified for ultra high, high, medium and low frequencies.

TOLERANCES:
Modern facilities permit rigid adherence to the most critical mechanical and electrical specifications.

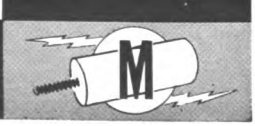
TOOLING:
Tools, dies and fixtures designed and built on the premises for unimpeded, uniform production.

PRODUCTION:
Modern, automatic production assures high speed economy; guarantees "on time" delivery at all times.

MOLDITE CAPABILITIES — engineering and production — are integrated to meet your iron core requirements with speed, precision and economy. Any size run and the most critical specifications can be efficiently handled with product uniformity assured throughout. Further, the capable MOLDITE engineering staff offers experienced guidance in meeting present and post-war iron core requirements for any size coil or transformer.

Write for Moldite Engineering Bulletin 100

NATIONAL *MOLDITE* COMPANY
25 MONTGOMERY STREET, HILLSIDE 5, NEW JERSEY



N. J. He also plans to resume construction on f-m station WGHF, New York.

AWARDS

Workers of the following concerns in the electronics field have been awarded Army-Navy burgees for excellence in production:

Eastern Amplifier Corp.
New York, N. Y.

National Union Radio Corp.
Robesonia, Pa.

The Workshop Associates
Newton Highlands, Mass.

The Bureau of Ordnance E has been awarded to the following firm for cooperation on the VT-fuze project:

International Resistance Co.
Philadelphia, Pa.

Surplus Parts and Equipment Agents

THREE LISTS handling government surplus electronic parts and equipment of manufacturer-agents have been released by RFC (Reconstruction Finance Corp.). They cover agents for component parts, agents for complete gear of their own make, and agents who will dispose of products of other concerns as well.

COMPONENT PARTS

Company	Address	Component
Advence Transformer	1161 W. Madison St. Chicago, Ill.	Transformers
Air Design & Fabrication, Inc.	241 Fairfield Ave. Upper Darby, Pa.	Transformers
American Phenolic Corp.	1830 So. 54th Ave. Chicago 50, Ill.	
American Transformer Corp.	178 Emmet St. Newark, N. J.	Transformers
Amperex Electronic Corp.	79 Washington St. Brooklyn, N. Y.	Power Tubes
Anco Products Co.	932 Market St. Paterson, N. J.	Transformers
Arco Transformer & Elec. Div. National Mill Supply Co.	207 E. Columbia St. Fort Wayne, Ind.	Transformers
Barker and Williamson Co.	235 Fairfield Ave. Upper Darby, Pa.	Capacitors, Coils
Best Mfg. Co.	1200 Grove St. Irvington, N. J.	Transformers, Coils, Speakers, Microphones, Head Sets
James G. Biddle Co.	1211 Arch St. Philadelphia 7, Pa.	Vibrating Reed Tachometers, Vibrating Reed Frequency Meters
Bogue Electric Co.	37 Kentucky Ave. Paterson, N. J.	Electronic Components and Equipments
Burlington Instrument Co.	106 N. 4th St. Burlington, Iowa	Panel Instruments, Meters
Capacitron Co.	849 No. Kedzie Ave. Chicago 51, Ill.	Capacitors

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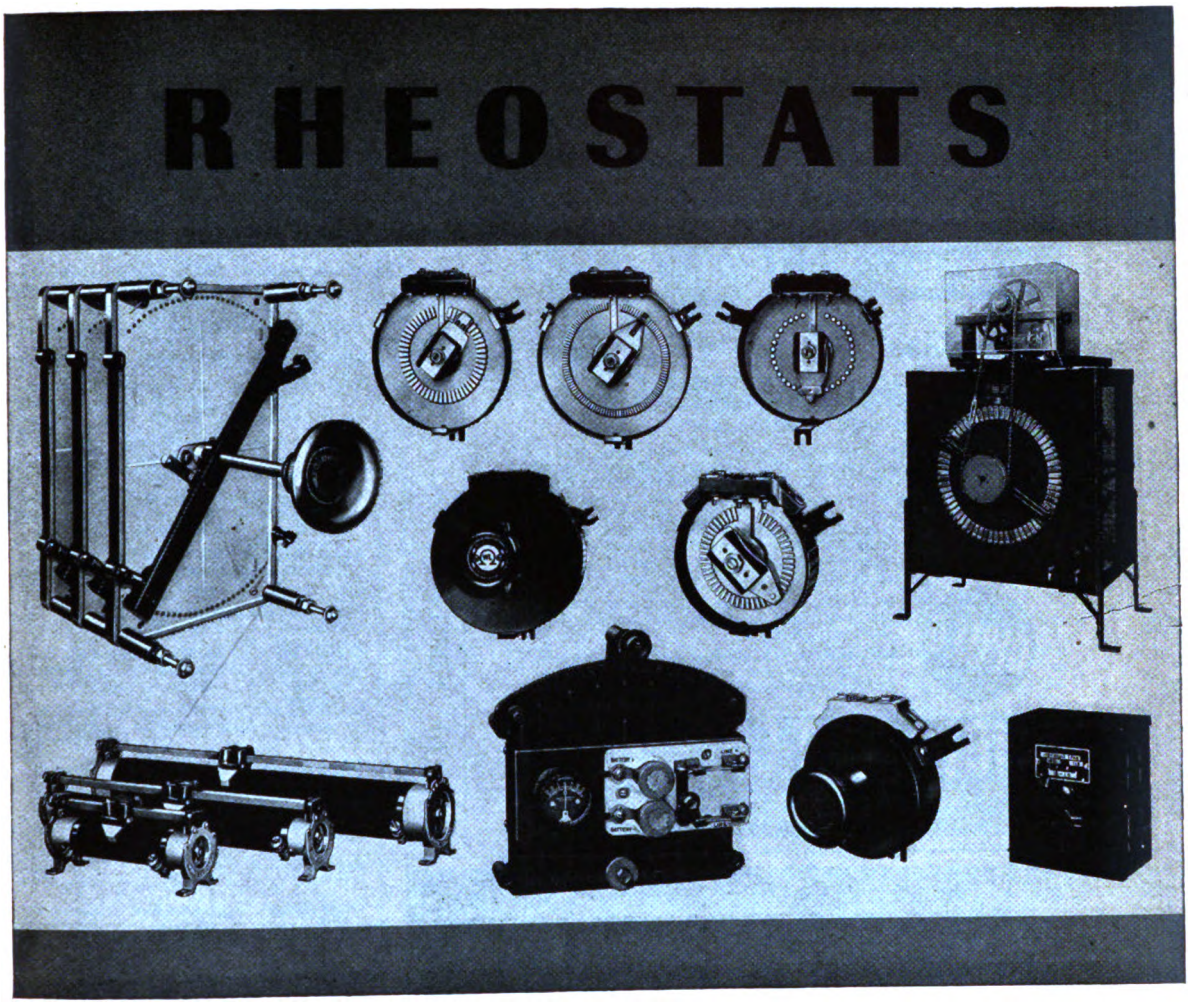

The Ward Leonard line of rheostats includes the widest range of sizes, tapers and current ratings from the tiny types for radio to huge multiple assemblies for the heaviest industrial use. Smooth operation, durable contacts and extreme dependability characterize all Ward Leonard Rheostats, Resistors and Relays. Write for bulletins of interest to you.

WARD LEONARD

RELAYS • RESISTORS • RHEOSTATS

ARMY E NAVY

Electric control (WL) *devices since 1892.*

WARD LEONARD ELECTRIC COMPANY · 32 SOUTH ST. · MOUNT VERNON, N. Y.

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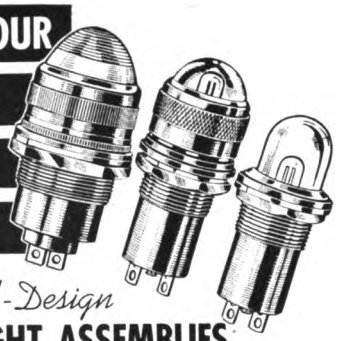
PERFECT YOUR POST-WAR PRODUCTS WITH DIALCO



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GREATER emphasis on *functional* design is the trend in post-war engineering of Electrical-Electronic Products. Mindful of this fact, Dialco has produced a line of Pilot Lights calculated to meet readily all post-war requirements. Comprising Warning-and-Signal Pilot Lights, Panel Lights, Jewel Assemblies, and Socket Assemblies, the Dialco line offers unlimited variations in functional design, size, shape, electrical characteristics, color, finish, etc. Special emphasis on applications of NEON Glow Lamps.

Let our Engineering Dept. help you select the *Pilot Light best suited to the functional design of your post-war product.*

PLUS LAMPS: To help speed production, we offer Pilot Lights completely assembled with the required General Electric or Westinghouse Lamps.

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QUALITY CONTROL of MICA

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FOR EVERY RADIO ELECTRICAL AND ELECTRONIC USE

We have consistently maintained Quality Control over production of fabricated mica parts, including those for the exacting requirements of radio and electronic fields. Close tolerances on dimensional measurements are attained by our use of the most advanced equipment in optical magnification and contour measurement. The raw mica is continuously inspected to assure high dielectric value.

Our entire personnel is trained to be quality-minded, which means ingrained accuracy and integrity. By use of our Incentive System, employees have much to gain by conscientious work. Our thorough Training Program makes it easy for employees to adhere closely to the high standards we demand. We invite discussion of your particular needs.

Established 1917

FORD RADIO & MICA CORP.

Joseph J. Long, President

538 63rd St., Brooklyn 20, N. Y.

Telephone: Windsor 9-8300

Company	Address	Components
Carborundum Co. (Globar Div.)	Hyde Park Blvd. Niagara Falls, N. Y.	Resistors
Allen D. Cardwell Mfg. Co.	81 Prospect St. Brooklyn 1, N. Y.	Capacitors
Chatham Electronics	475 Washington St. Newark, N. J.	Radio Tubes
Chicago Condenser Corp.	3917 Fullerton Ave. Chicago, Ill.	Capacitors
Chicago Industrial Instrument Co.	219 W. Chicago Ave. Chicago, Ill.	Electronic and Associated Equip.
Chicago Transformer Div. Essex Wire Corp.	4216 W. Irving Park Rd. Chicago, Ill.	Transformers, Resistors
Cinch Mfg. Corp.	2335 West Van Buren St. Chicago 12, Ill.	Electronic Component Parts
C. P. Clare & Co.	4719 Sunnyside Ave. Chicago 30, Ill.	Switches, Relays
Cole Instrument Co. (Electric Products Service)	1320 So. Grand Ave. Los Angeles, Cal.	Meters, Test Equipment
Consolidated Radio Products Co.	350 W. Erie St. Chicago 10, Ill.	Head Sets, Transformers, Speakers
Continental Electric Co.	715 Hamilton St. Geneva, Ill.	
Control Corp.	600 Stinson Blvd. Minneapolis, Minn.	Coils, Transformers, Chokes
Cords Ltd., nc.	126 Orchard St. Newark, N. J.	Cord Sets, Electrical Components
Cosmic Radio Corp.	699 E. 135th St. New York 54, N. Y.	Capacitors
Daven Company	191 Central Ave. Newark, N. J.	Resistors
Dean W. Davis & Co., Inc.	Kentland, Indiana	Transformers, Coils, Solenoids
De Jur Amsco Corp.	Northern Blvd. at 45 St. Long Island City 1, N. Y.	Electric Meters, Potentiometers
Tobe Deutschmann Corp.	863 Washington St. Canton, Mass.	Capacitors, Filters, Noise Meters
Dumont Electric Company	34 Hubert St. New York, N. Y.	Capacitors
Thos. A. Edison, Inc.	51 Lakeside Ave. West Orange, N. J.	Panel Instruments
Eitel-McCullough, Inc.	525 West 13th St. Salt Lake City, Utah	Tubes, Capacitors, Relays
Electrical Reactance Corp	49 Elm St. Franklinville, N.Y.	Resistors, Capacitors, Choke Assemblies
Electrical Utilities Co.	La Salle, Ill.	Paper Capacitors
Electrical Windings, Inc.	2015 No. Kolmar Ave. Chicago, Ill.	Transformers, Coils
Electricoil Transformer Co.	421 Canal St. New York, N. Y.	Transformers, Reactors, Chokes, Coils, Rectifiers
Electro-Motive Mfg. Co.	So. Park & John Sts. Willimantic, Conn.	Capacitors
Electronic Development Co.	1336 N. Saddle Creek Rd. Omaha 3, Nebr.	Panel Instruments, Test Equipment, Noise Filters
Electronic Engineering Co.	733 W. Ohio St. Chicago, Ill.	Transformers, Chokes, Wave Filters
Electronic Enterprises, Inc.	67 Seventh Ave. Newark 4, N. J.	Transmitting Tubes
Electronic Transformer Co.	205 W. 25 St. New York, N. Y.	Transformers
Electro-Voice Corp.	1239 So. Bend Ave. South Bend, Ind.	Microphones

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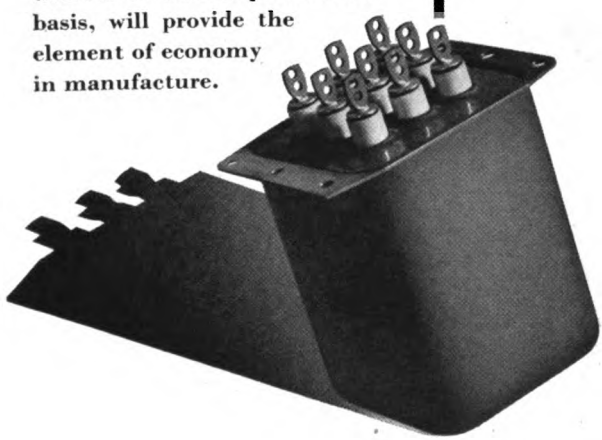
Company	Address	Component
Erie Resistor Corp.	644 W. 12th St. Erie, Pa.	Resistors, Capacitors
John E. Fast & Co.	3123 No. Pulaski Rd. Chicago 41, Ill.	Capacitors, Choke Coils
Federal Telephone & Radio Corp.	591 Broad St. Newark, N. J.	Radio Component Parts
General Electric Co.	Bldg. 267, River Rd. Schenectady, N.Y.	Electron Tubes
General Electronics, Inc.	1819 Broadway New York 23, N. Y.	Power Tubes]
Glenn-Roberts Co.	3100 E. 10 St. Oakland 1, Calif.	Transformers, Capacitors, Chokes
Gruen Watch Co.	Cincinnati, Ohio	Panel Indicating Instruments
Guardian Electric Mfg. Co.	1400 Washington Blvd. Chicago 7, Ill.	Relays, Solenoids
Hammarlund Mfg. Co.	460 W. 34 St. New York 1, N.Y.	Resistors, Capacitors
Hercules Electric & Mfg. Co., Inc.	2500 Atlantic Ave. Brooklyn 7, N. Y.	Transformers, Reactors, Choke Coils, Inductors
H.R.S. Radio Products	5707 W. Lake St. Chicago, Ill.	Capacitors
Hudson American Corp.	25 W. 43 St. New York 18, N. Y.	Transformers, Electronic Components
Hytron Radio & Electronics Corp.	76 Lafayette St. Salem, Mass.	Receiving and Transmitting Tubes]
Illinois Condenser Co.	1160 No. Howe St. Chicago, Ill.	Capacitors
Industrial & Commercial Electronics	P.O. Box 896, Belmont, Calif.	Transmitting Tubes, Vacuum Condensers, Components
Industrial Condenser Corp.	3243—65 No. Calif. Ave. Chicago 18, Ill.	Capacitors
Industrial Transformer Corp.	2340 Belmont Ave. New York 58, N. Y.	Transformers
Insuline Corp. of America Inc.	3602 35 Ave. Long Island City, N. Y.	Various Electronic Products
International Resistance Co.	401 No. Broad St. Philadelphia, Pa.	Resistors
Jensen Radio Mfg. Co.	6601 So. Laramie Ave. Chicago 38, Ill.	Speakers, Transformers
E. F. Johnson Co.	206 Second Ave., S. W. Waseca, Minn.	Capacitors, Hardware, Inductors
Ken-Rad Div. General Electric Co.	3rd & St. Elizabeth Sts. Owensboro, Kentucky	Receiving and Transmitting Tubes
Lewis Electronics	16 Lyndon St. Los Gatos, Calif.	Transmitting Tubes
Light Electric Company	214 Lackawanna Ave. Newark 4, N. J.	Transformers
Madison Electrical Products Corp.	78 Main St. Madison, N. J.	Resistor
Meguire Industries	500 Fifth Ave. New York, N. Y.	Transformers
Micamold Radio Corp.	1087 Flushing Ave. Brooklyn, N. Y.	Capacitors, Resistors
August C. Miller Co.	9226 Hudson Blvd. N. Bergen, N. J.	Crystal Assemblies
Milwaukee Resistor Company	130-A West Pittsburgh Milwaukee, Wisc.	Resistors
Muter Company	1255 So. Michigan Ave. Chicago, Ill.	Resistors, Coils' Capacitors Switches
National Scientific Products Co.	5013-25 No. Kedzie Ave. Chicago 25, Ill.	Crystal Oscillators, Headsets, Portable Electric Megaphones

An Announcement To Those Who Require *The Best*

THIS advertisement is addressed to the manufacturers of electronic equipment whose product demands the best in component parts—who will want the best in transformers, *if* "the best" is offered at a price that will fit the cost specifications of their finished product.

By adapting to peace-time use the major features of the Hermetically-Sealed transformer construction that won war-time leadership, Chicago Transformer is prepared to provide the best in transformers to those who require them. Fully developed basic mounting parts, when utilized on a mass production basis, will provide the element of economy in manufacture.



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NEW SOLDERING GUN

THE SPEED IRON*

Soldering Heat in 5 Seconds

Wherever you have a soldered joint in radio, electrical or electronic repair and service work, the Speed Iron will do the job faster and better.

The transformer principle gives high heat—in 5 seconds—after you press the trigger switch. Convenient to hold with a pistol grip handle, the compact dimensions of this new soldering tool permit you to get close to the joint. The copper loop soldering tip permits working in tight spots. The heat is produced by the high current flowing through the soldering tip—permitting direct and fast transfer to the soldered connection.

If you want to save time on soldering jobs with a tool that is ready to use in 5 seconds, get a Speed Iron today. See your radio parts distributor or write direct.

***T.M. Reg U. S. Pat. Off.**

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DEPT. E-1 • EASTON, PA.

REGULATED POWER SUPPLY

250-450 VOLTS

Wide fields of application have been opened up both in research and industry for this unit. A-C ripple is negligible and extreme care has been taken to eliminate high-frequency noise. Regulated power supply units are invaluable for such applications as amplifiers, television pulse generators, constant frequency oscillators, and measuring equipment.

Other G-E regulated power-supplies are available in the following ranges: **180-300 volts 160-1500 volts Dual Regulated**

Write today: Electronics Department, Specialty Division, General Electric, Syracuse, N. Y.

GENERAL ELECTRIC

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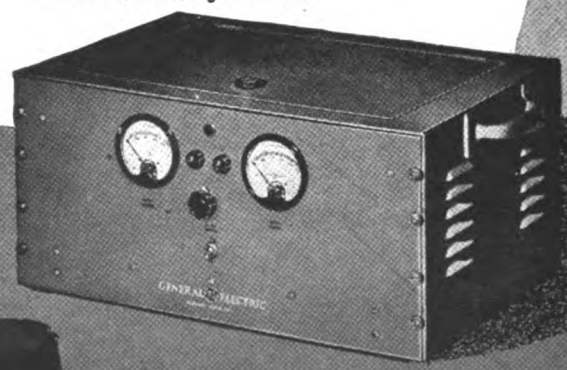
Electronic Measuring Instruments



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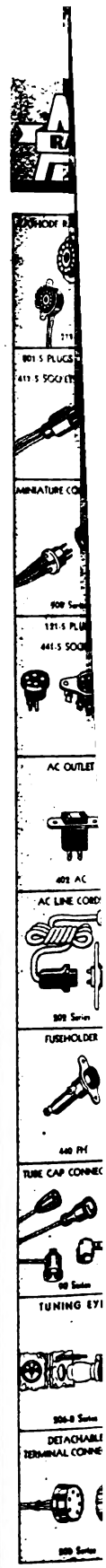

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Company	Address	Component
National Union Radio Corp.	15 Washington St. Newark, N. J.	Receiving and Transmitting Tubes
Newark Transformer Co.	17 Frelinghuysen Ave. Newark, N. J.	Transformers, Reactors
Newton Co.	244 W. 23 St. New York 11, N. Y.	Transformers
New York Transformer Co.	26 Waverly Pl. New York 3, N.Y.	Transformers
North American Philips Co., Inc.	100 E. 42nd St. New York, N. Y.	Electron Tubes
Ohio Carbon Co.	12508 Berea Rd. Cleveland, Ohio	Resistors
Oxford-Tartak Radio Corp.	3911 S. Michigan Ave. Chicago, Ill.	Speakers
Permoflux Corp.	4900 West Grand Ave. Chicago 39, Ill.	Headsets, Speakers
Precision Resistor Co.	334 Badger Ave. Newark 8, N. J.	Resistors
Premier Electronics Products, Inc.	4849 North Western Ave. Chicago, Ill.	Transformers
Presto Electric Co.	4511 New York Ave. Union City, N. J.	Resistors
Quam-Nichols Co.	33 Pl. & Cottage Grove Ave. Chicago 16, Ill.	Speakers
Radio Corporation of America RCA Victor Div.	Camden New Jersey	Electron Tubes
Radio Development & Research Corp.	233 W. 53 St. New York, N. Y.	Electronic Equipment
Radionic Controls	3758 W. Belmont Ave. Chicago 18, Ill.	Relays, Transformers
Raytheon Mfg. Co.	55 Chapel St. Newton 55, Mass.	Receiving and Transmitting Tubes, Transformers
R-B-M Mfg. Co. Div. Essex Wire Corp.	Logansport Indiana	Relays
Red Arrow Electric Corp.	132 Lincoln Pl. Irvington, N. J.	Transformers
Reimers Elec. Appl. Co., Inc.	596 56 St. West New York, N. J.	Wire Wound Resistors
Sangamo Electric Co.	11th & Converse St. Springfield, Ill.	Capacitors
Shallcross Mfg. Co.	Jackson & Pusey Ave. Collingdale, Pa.	Resistors
F. W. Sickles Co.	165 Front St. Chicopee, Mass.	Capacitors, Coils, Chokes, Subassemblies, Potentiometers
Simpson Electric Co.	5218 West Kinzie St. Chicago, Ill.	Panel Instruments, Test Equipment
Slater Mfg. Co.	728 Atlantic Ave. Brooklyn, N. Y.	Power Tubes
Sola Electric Co.	2525 Clybourn St. Chicago, Ill.	Transformers
Solar Mfg. Corp.	285 Madison Ave. New York 17, N. Y.	Capacitors
Sonotone Corporation	Elmsford, New York	Tubes, Headsets, Transformers
Speaker Corp. of Chicago	230 W. Superior St. Chicago, Ill.	Speakers
Sperti, Inc.	Beech & Kenilworth Ave. Cincinnati, Ohio	Electron Tubes
Standard Arcturus Corp.	30-34 Court St. Newark 2, N. J.	Receiving Tubes
Standard Coil Products Co.	2329 No. Pulaski Rd. Chicago, Ill.	Radio Coils, Crystals

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Huge stocks in *two* convenient warehouses—one in CHICAGO and one in ATLANTA—are ready to supply you quickly with needed parts of dependable, nationally-known quality—and at VICTORY CLEARANCE prices that mean real savings. Mail the coupon below NOW for your FREE copy of CONCORD'S VICTORY CLEARANCE Flyer.

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D. C. Milliammeters

2½" flange mtg. type. Metal case dull black finish. G. E. 0-200 M. A. C10650
Specially Priced **$4.95**

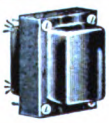


Plate Power Transformer

Pri. tapped at 115, 117 and 120 V.A.C. Sec. output 850 V. at 200 ma. c. t. 4½" L x 3¾" W x 3⅞ W H. 5B5035.
Your cost **$4.29**

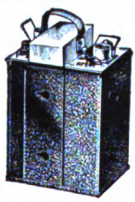
Dry Electrolytic Condenser

Hermetically sealed. Size, 1⅜" x 3". Can negative. Cap.: 40 mfd. at 475 volts; 15 mfd at 350 volts; 15 mfd at 150 volts; 20 mfd at 25 volts. 5B-3161 Each **59c**

Output Transformer

Hermetically sealed. Six studs, 1, 2, and 3 are pri. 4, 5, and 6 the sec. Pri. ind. at 5 V. 1000 cy.: .20 H. Ratio sec. to pri. 3.02:1. size: 3¾" x 2¼" 5B-5045 Your cost **$1.95**

Mobile High Voltage Power Unit



Input 12 V at 10 amps. Output consists of two voltage ranges: (1) 275 at 110 ma. (2) 500 at 50 ma. 5B9518
Your cost **$39.50**

300 Watt Rheostat

Wire wound. Vitreous enameled. Cast aluminum base. 6" dia. 2⅛ 2 deep, 1400 ohms. 5B9517
Your cost **$3.95**

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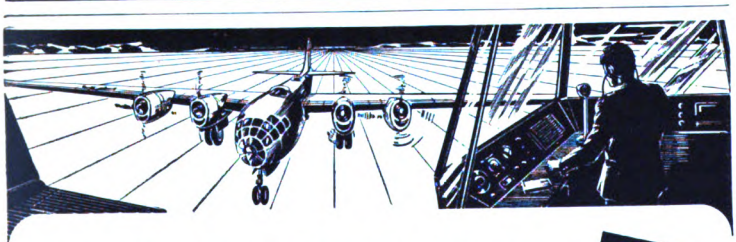

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TRY SILVER GRAPHALLOY

for RELAYS MOTORS CONTROLS ELECTRONICS

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High current density, low contact drop, low electrical noise, and self-lubrication are characteristics of this silver-impregnated molded graphite that may be the answer to your electrical brush problems

FOR CONTACTS

Low contact resistance and non-welding when breaking surge currents are inherent properties of this unique combination of conductive silver and self-lubricating graphite

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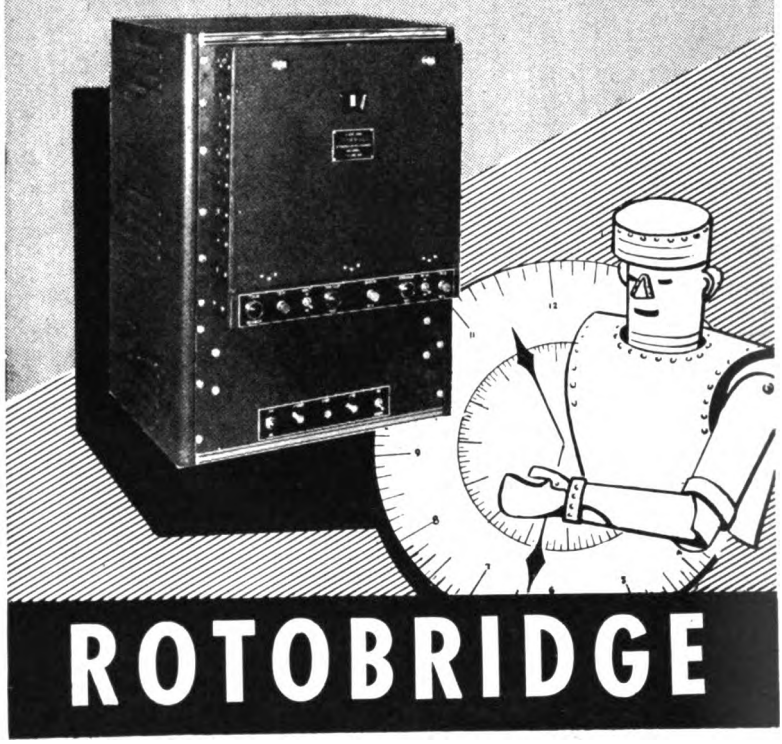
Company	Address	Component
Standard Transformer Corp.	1500 No. Halsted St. Chicago, Ill.	Transformers, Chokes, Reactors
Super Electric Products Corp.	1057 Summit Ave. Jersey City, N. J.	Electronic Equipment, Transformers, Switches
Supreme Instruments Corp.	Howard St. Greenwood, Miss.	Radio Testing Equipment
Sylvania Electric Products, Inc.	Emporium, Pennsylvania	Electron Tubes
Taylor Tubes, Inc.	2342 Wabansia Ave. Chicago 47, Ill.	Transmitting Tubes
Tech Laboratories	337 Central Ave. Jersey City 7, N. J.	Resistors
Thermador Electrical Mfg. Co.	5119 S. Riverside Dr. Los Angeles 22, Calif.	Transformers, Chokes, Reactors
Thordarson Electric Mfg. Div. Maguire Industries	500 West Huron St. Chicago, Ill.	Transformers Coils
Transformer Products, Inc.	143 W. 51 St. New York, N. Y.	Transformers
Translite, Inc.	639 Kent Ave. Brooklyn 11, N.Y.	Power Tubes
Trefz Mfg. Co.	38-11 Main St. Flushing, N. Y.	Resistors, Test Equipment
Triplett Electrical Instrument Co.	Harmon Road Bluffton, Ohio	Panel Instruments
Tung-Sol Lamp Works, Inc.	95 Eighth Ave. Newark 4, N. J.	Receiving and Power Tubes
Underwood Electric & Mfg. Co., Inc.	3120 W. Grand Ave. Chicago 22, Ill.	Capacitors
United Electronics Co.	54 Spring St. Newark, N. J.	Transmitting Tubes
United Transformer Co.	150 Varick St. New York 13, N. Y.	Transformers, Reactors, Filters
Universal Microphone Co.	Centinela at Warren Lane Inglewood, Calif.	
Ward Leonard Electric Co.	31 South St. Mt. Vernon, N. Y.	Resistors
Weston Electrical Instrument Corp.	614 Frelinghuysen Ave. Newark 5, N. J.	Panel Instruments
Winters & Crampton Corp.	Granville, Michigan	Capacitors

EQUIPMENT OF OWN MAKE

Company	Address
Air Communications, Inc.	2233 Grand Ave. Kansas City, Mo.
A.R.F. Products	7713 West Lake St. River Forest, Ill.
Automatic Radio Mfg. Co., Inc.	122 Brookline Ave. Boston, Mass.
Aviola Radio Corp.	703 W. Ivy St. Glendale, Calif.
Belmont Radio Corp.	5921 West Divkens Ave. Chicago, Ill.
James G. Biddle Co.	1211 Arch St. Philadelphia 7, Pa.
Allen D. Cardwell Mfg. Corp.	81 Prospect St. Brooklyn 1, N. Y.
David Bogen Co., Inc.	633 Broadway New York, N. Y.
Bruno-New York, Inc.	460 W. 34th St. New York 1, N. Y.
Communication Measurements Lab.	120 Greenwich St. New York, N. Y.
Communications Co., Inc.	2700 Ponce de Leon Blvd. Coral Gables, Fla.
Cover, Dual Signal Systems, Inc.	5217 North Ravenswood Ave. Chicago, Ill.
Crosley Corp.	1325 Arlington St. Cincinnati, Ohio
Daven Co.	191 Central Ave. Newark, N. J.

Speed Your Production With This Money-Saving Automatic Inspector



ROTOBRIDGE

Checks a Circuit a Second!

Instantaneous and accurate, the Rotobridge functions with robot-like fidelity in checking wiring errors, resistance and reactance values.

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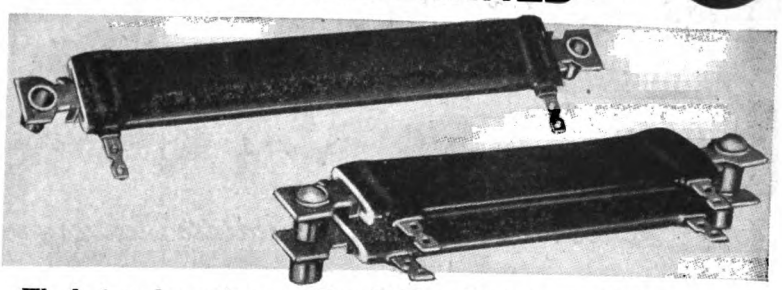

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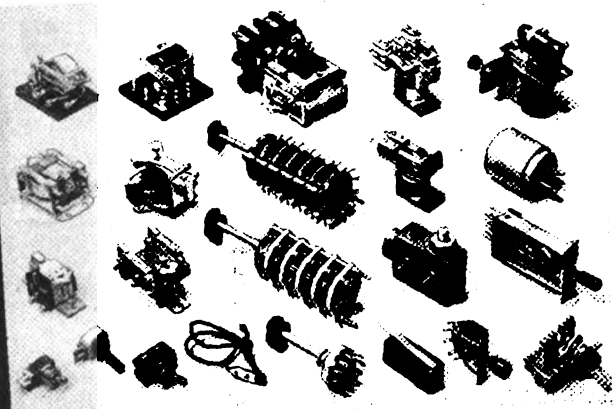

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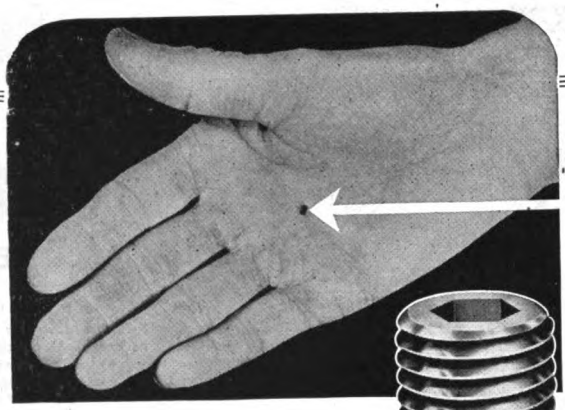

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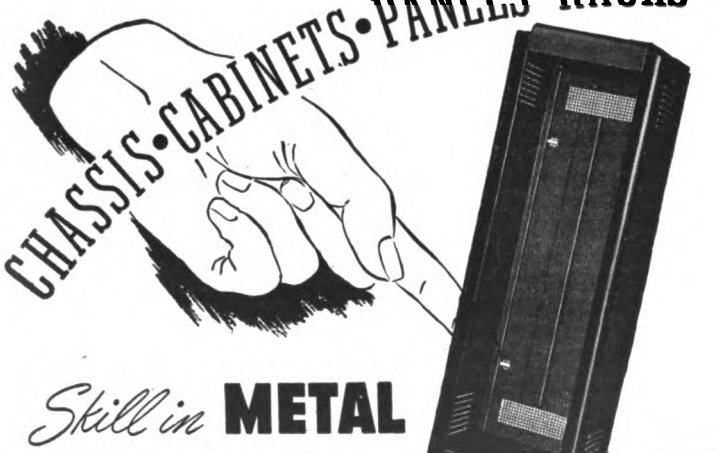

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By MATHEMATICAL TABLES PROJECT, *sponsored by National Bureau of Standards, Columbia University Press, New York, N. Y., 1945, 124 pages, $3.50.*

A 12-PLACE TABLE of values of arc sin x, in radian measure, prepared as a companion volume to the values of arc tan x published by the Mathematical Tables Project in 1942. Since, for the principal value, arc cos $x = \frac{1}{2}\pi$ − arc sin x, this volume may also be used for obtaining the inverse cosine. Specifically, the function is tabulated at intervals of 0.0001 in the range between 0 and 0.9890 and at intervals of 0.00001 in the range between 0.98900 and unity.

Also included are 15-place conversion tables for changing radians to degrees, degrees to radians, minutes to radians, and seconds to radians, along with a 15-place table of multiples of $\pi/2$ up to 100.—J.M.

• • •

Principles of Radio

By KEITH HENNEY, *Editor,* ELECTRONICS. *John Wiley & Sons, Inc., New York, 534 pages, $3.50.*

THIS FIFTH EDITION of a successful textbook shows promise of increasing its popularity which was well established by former editions over a period of fifteen years.

Although completely revised and brought up to date by the addition of new material on wave guides, microwaves, frequency-modulation broadcasting, klystron tubes, and other advances in the field the contents adhere to the original intention of the author, that of being written for the student who had little background in radio upon which to build and yet who wanted to know the basis on which radio communication existed. The omission in this edition of the chapters on Radio Frequency Amplifiers and Facsimile and Television in favor of new material does not detract from the continuity of the book.

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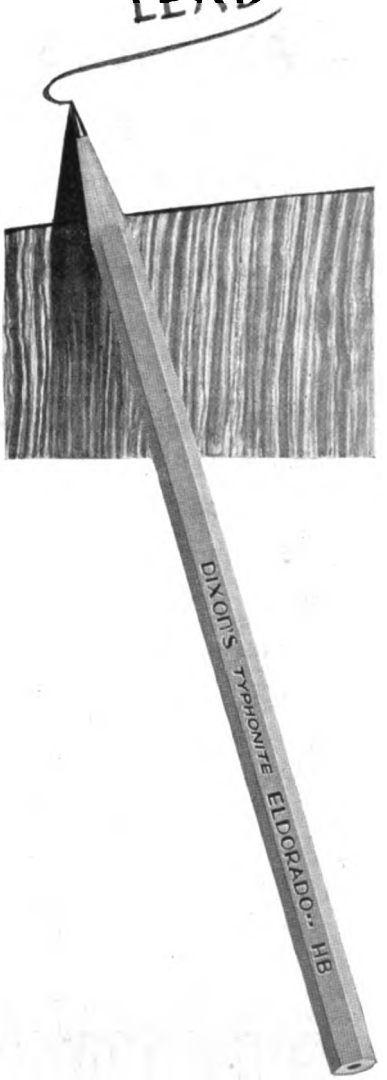

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practical examples and problems. The beginner should encounter little difficulty in gaining an understanding of the basic circuits employed in radio communication equipments.

It is noted that the author has been careful in adhering to a consistent form of abbreviation and notation. A minor objection is his refusal to make a clean break with the direction of "conventional current flow." Furthermore, it is considered unfortunate that inductors and capacitors continue to be called coils and condensers respectively. However, these do not measurably lessen the value of the book as a good basic radio textbook.—NELSON M. COOKE.

• • •

The Decibel Notation

By VEPA V. L. RAO, *Addison & Company, Ltd., Madras, India, 179 pages, $3.00.*

TODAY THE DECIBEL UNIT is widely used in radio engineering and acoustics. In 1924, when it was first used in telephone engineering, it was called a transmission unit. In the intervening twenty years, however, very few textbook authors and technical writers have devoted their efforts to the preparation of a thorough treatment of this important mathematical artifice. To fill this void in engineering literature, Vepa V. L. Rao, radio engineer, Government of Madras, has contributed this excellent monograph, the complete title of which is "The Decibel Notation and Its Applications to Radio Engineering and Acoustics."

As presented, the definitions, mathematical operations and procedures can be easily comprehended by anyone who has studied electrical engineering. The book should serve as a valuable reference work to all who are engaged in fields associated with telecommunications and acoustics.

To orient the reader, the author begins with an exposition contrasting the precision with which pressure, temperature, sound intensity, frequency change, and intensity of illumination can be measured, with the difficulties encountered in measuring the sensations of feeling, heat, loudness, pitch, and brightness. He next surveys the develop-

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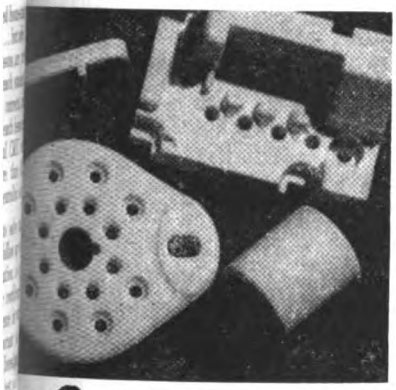

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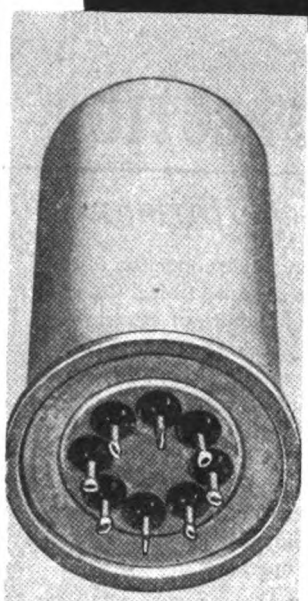

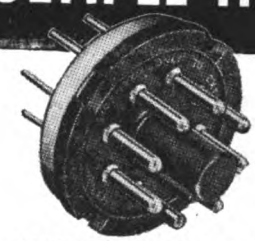

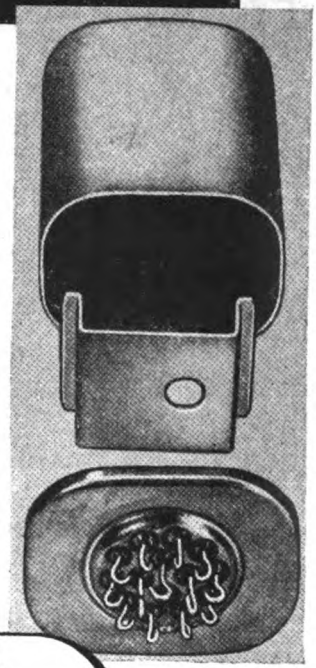

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Following a discussion and definition of the important terms used in acoustics, the phon or loudness unit is introduced and its development traced. For a plane progressive wave, comparative values are given in tabular form for the intensity level, phons, corresponding effective value of pressure fluctuations, and sound particle velocity. The zero phon loudness level is defined and a comparison made of the loudness levels in phons of the thresholds of hearing, feeling, and pain.

In showing how the decibel notation is used in radio engineering and acoustics, the author takes the opportunity to describe the principles underlying the use of many well known devices and their characteristics. The applications include the output power meter, audio amplifiers, radio receivers, audio transformers, gramophone record cutters and pickups, output tubes, microphones, loudspeakers, transmitters, transmission lines and feeders, antennas, studio acoustics, attenuators, equalizers, and filters.

An appendix is devoted to a description of the types of graphs used in radio and acoustic engineering, an explanation of the logarithmic notation and its limitations, a discussion of the differences between the British and American standard cables, and a statement of the laws of logarithms with tables of common logarithms and antilogarithms.—J.K.

• • •

The Electrolytic Capacitor

By ALEXANDER M. GEORGIEV, *Murray Hill Books, Inc., New York 16, N. Y., 191 pages, $3.00.*

ENGINEERS WHO DESIGN and develop electrical apparatus and products that make use of electrolytic capacitors will appreciate the broad scope of this book. The well-balanced presentation of fundamental principles and practical considerations is convincing evidence that the author is an authority in this field.

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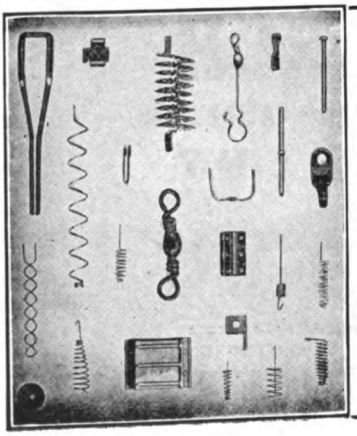

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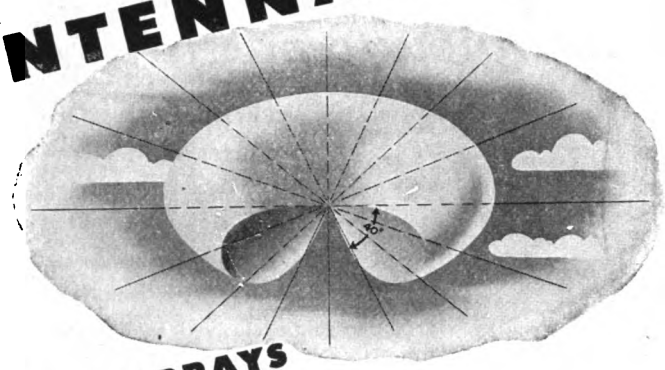

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Several theories are outlined concerning the nature of the dielectric film, and the properties of the film treated in detail. Film-forming electrolytes that are generally used in the electrolytic capacitor industry are thoroughly surveyed as well as those employed in other branches of the anodizing process. The batch method and the continuous method, and associated equipment, used in the formation of capacitor anodes are set forth.

Much detailed and useful information is included in the chapters dealing with chemical and electrochemical methods of etching aluminum electrodes to increase capacitance, properties of papers suitable for electrode spacers in dry electrolytic capacitors, properties and requirements of materials used for the operating electrolyte, precautions and considerations that must be observed in winding capacitor sections and their connections if satisfactory performance is to be obtained, factors governing the effectiveness of the impregnation and precautions necessary to produce desired results, methods of impregnating dry capacitors and their respective advantages and drawbacks, and the requisites for an efficient container including a discussion on methods of venting the assembly.

For the laboratory technician and the maintenance man, chapters are included that cover electrical measurements, routine tests and special tests for electrolytic capacitors, causes and detection of troubles, emergency repairs, and replacements.

Of special interest to designers of electrical apparatus and assemblies are the sections devoted to the choice of type and design of electrolytic capacitors as governed by expected operating conditions, available space for mounting, permissible weight, cost, and similar factors, trends in the development of electrolytic capacitors during the

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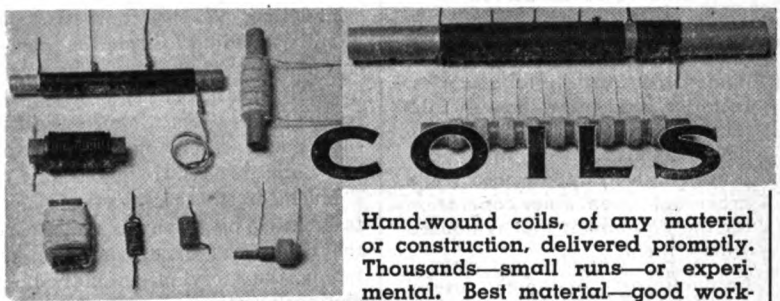

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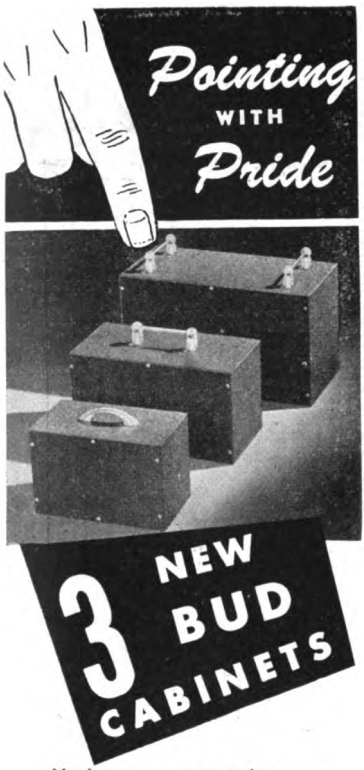

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last twenty years, and applications and uses for electrolytic capacitors in radio receivers, electrical apparatus, and induction motors.

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By JOHN T. BRODERICK. *Fort Orange Press, Inc., Albany, New York, 324 pages, $3.00.*

IN THE FOREWORD of this book, Karl T. Compton states "Few scientists have so impressed their ideals upon their contemporaries and followers as has Willis R. Whitney. He has largely set the pattern and philosophy of the modern industrial research laboratories, one of the unique achievements of this century. That Whitney was able to do this may be explained very simply; he was the right man at the right place at the right time.

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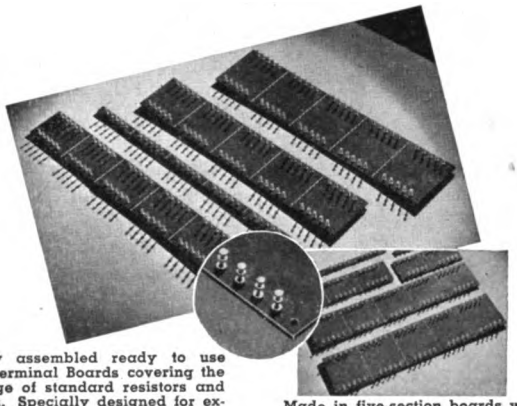

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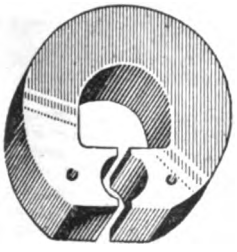

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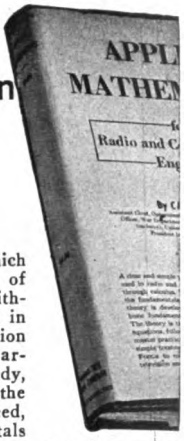

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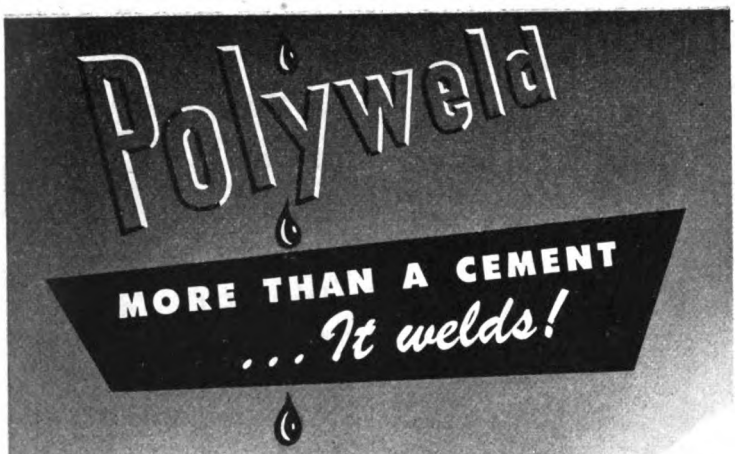

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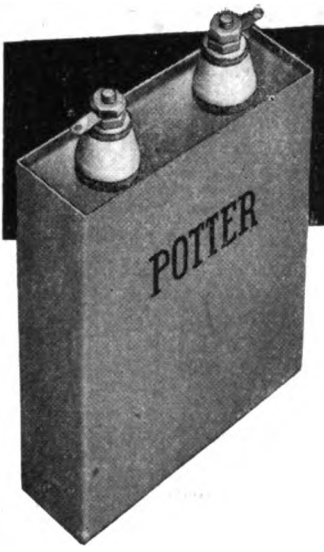

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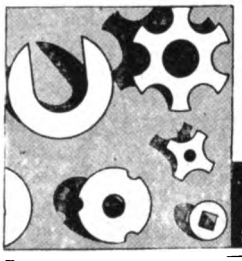

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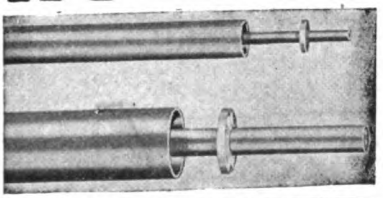

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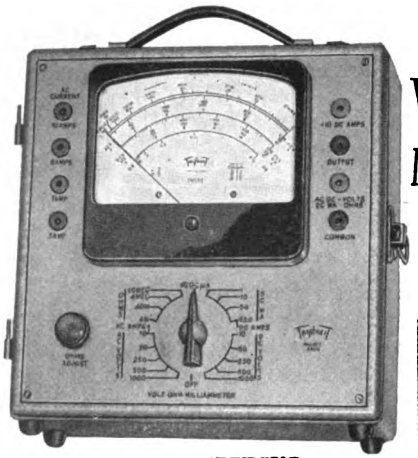

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I think that Mr. Craig's proposed exception can be shown to be quite invalid with a moment's thought. The television system that I think he describes has been put forward before, and has never been of any practical use. Let's consider just one out of the 240,000 elementary areas. The information determining the density of this area would have to be passed through a narrow-band filter; in the example given this filter is one-quarter cycle wide.

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mined by the bandwidth of the filter. "You can't get 20-kc audio signals out of a radio having an i-f bandwidth of 4 kc" is another way of saying the same thing. A band-pass filter having a bandwidth of about one-quarter cycle would require 8 to 10 seconds for the output to build up to a value approximating the final steady-state value if a suddenly changed voltage were applied to the input.

This means that if the picture at the transmitter were suddenly changed, the receiver would require 8 to 10 seconds to remove the old picture and reproduce the new one. In order to transmit a new picture each one-thirtieth of a second, the band-pass associated with each picture element would have to be approximately 60 cycles wide. Actually, according to present day practices, a bandwidth of 30 cycles would be sufficient. This would still require a total spectrum about 7 mc wide, or about the order of magnitude of present day practice.

The system described by Mr. Craig might be fine for a Hollywood clinch with a long fadeout at the end, but I'd hate to watch a boxing match or baseball game on it.

WM. H. UNGER
Philharmonic Radio Corp.
New York, N. Y.

[The motion is still before the house that the following statement be called the Hartley Law: "The total amount of information which can be transmitted over a system whose transmission is limited to frequencies lying in a restricted range is proportional to the product of the frequency-range which it transmits by the time during which it is available for transmission." Any further comments?—Ed]

• • •

INSTRUMENT FLYING

Wave Jean Gaum gives directions to a Naval officer shut in the Link trainer in the background

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STEADY JOBS *and* EQUIPMENT BUYING

SUSTAINED employment is not an attainable goal unless we can moderate the erratic fluctuations which have characterized the markets for producers' equipment in past periods.

In the 35th editorial of this series, "Sustained Construction Activity", it was pointed out that there is no specific that can cure our economy of its "boom-or-bust" proclivities. Rejecting the notion that the construction industry could be so managed as to stabilize business as a whole, that editorial stressed the important contribution it could make to that end, and suggested several practical expedients through which construction activity might be regularized.

Producers' equipment represents an area of production quite as broad and diverse as construction, though smaller in aggregate value. The classification embraces all types of durable equipment bought and used for profit—locomotives, motor trucks, electric generators, conveyors, machine tools, farm implements, and so on down to surgical instruments and dentists' drills.

Although the output of such equipment averages over a long period only 5 or 6 per cent of the nation's total output, it resembles construction in its extraordinary ups and downs. While its component items differ widely in the amplitude and violence of their fluctuations, the class as a whole is one of the most unstable sectors of the economy, making therefore a quite disproportionate contribution to the cyclical swings of total production and employment. From 1929 to 1932, for example, the decline in the output of producers' equipment (at constant prices) was 65-70 per cent, in contrast to a decline of 25-30 per cent in the national output exclusive of such equipment and construction.

A more recent example of the volatility of demand in this field may be found in the movement of a monthly index of orders for industrial equipment, which rose from 92 in the spring of 1936 to 160 in the spring of 1937, falling thence to 65 in the summer of 1938 and rising again to 142 in the fall of 1939. Such fantastic oscillations present an obvious and inescapable challenge to all concerned with economic stabilization.

Not only are these fluctuations bad for the economy; they represent demonstrably bad buying policy on the part of the purchasers of equipment. Peaks in demand come characteristically just before a business depression (1919, 1929, and 1937, for example) when machinery costs the most to buy and install and when it has the lowest expectancy of continuous use. At exactly the wrong moment everyone wants to buy. In the depression itself, on the other hand, with costs down, and with nowhere for the economy to go but up, equipment is a drug on the market. No one wants it when it is cheap and has the greatest prospect for steady employment. Here is a behavior pattern so profoundly irrational there must be hope for its correction.

There is an inveterate tendency for business management to forecast the future simply by projecting the trends of immediate past. Although it is axiomatic that the chance for an extended period of further prosperity is inversely related to the duration of the prosperity already experienced, this truism is generally ignored. The longer the boom has run, the more certain is business management that it will continue indefinitely. Convinced at last by "actual experience" that prosperity is here to stay, executives give the green light to commitments for expansion and modernization previously deferred in a skeptical attitude of "wait and see". The result, so often repeated in our economic history, is an explosive burst of demand for equipment coincident with, and contributing to, the final spasm of a boom. Witness the phenomenal rise in industrial equipment orders during 1928 and the spring of 1929.

The same prophetic illusion works in reverse during a depression. Recent experience is projected into the future. Although the mathematical probability of an imminent and prolonged period of prosperity increases directly with the duration of a depression, it finds little reflection in business decisions. Timidity and caution are the order of the day.

Compounding the errors caused by faulty perspective, are a number of influences which make it extremely difficult for individual enterprises to follow a policy geared to sensible long-term considerations. In a boom, particularly in its climactic phase, most producers find their order books crowded beyond the potential of their current capacities and are faced with the alternatives of expanding or losing trade to competitors. In depression the situation is reversed, and producers with unused facilities find it difficult to justify increases in their capital charges.

An even more controlling factor in many cases is the availability of funds. This is especially important

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for small concerns. Typically such firms enjoy but limited credit, and with no ready access to the securities markets, their capital expenditures depend primarily on earnings. When they are making money, they can afford to buy equipment; when they are losing, they largely disappear from the equipment market. Even great enterprises, though less dependent on earnings as a source of capital financing, are profoundly influenced by the volume of internal funds available for the purpose, a volume as a rule far greater in prosperity than in depression. Moreover, it is usually easier in good times to obtain outside funds through the sale of stock or by borrowing, since in bad times bankers, underwriters, and investors are susceptible to the same timidity and caution that afflict business management generally.

We are dealing here with a combination of psychological, physical, and financial forces which conspire to aggravate the instability of demand for capital equipment. What can be done to reduce this instability and thus to bring equipment purchasing into a more sensible and constructive pattern?

There is no panacea, no royal road to the solution. The problem has been with us since the beginning of the industrial economy. It is complex and difficult. It is not, however, wholly intractable. We may reasonably hope that industry will, through intelligent effort, make substantial progress toward a satisfactory solution. The industrial equipment field is one in which government, except for war periods, has exerted little direct control. The best insurance against the institution of government measures is to so conduct activities in the equipment field that no justification for government interposition can be made.

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1. The first and most important step is for industry itself to reconsider its heretofore haphazard and opportunistic policy in the purchase of equipment, substituting so far as possible a regularized, long-range programming of expenditure that will resist both the excited long-buying of booms and the equally disturbing underbuying of depressions. Such long-range programming is particularly appropriate and advantageous for large enterprises in established industries such as railroads, electric power, steel, automobiles, and the like, but it makes sense much more generally.

Once executives come to realize that a reasonably stable equipment program contributes not only to the welfare of the economy but also to the lowering of their long-run equipment costs, the opportunity to combine a public service with private advantage should induce them to recast their policies accordingly.

There is an even more compelling reason for purchasers of industrial equipment to do everything possible to regularize their demands. Some concerns unquestionably will find themselves in a postwar position where speedy delivery of needed equipment, even though it involves the payment of premium prices, will seem to be justified. But there is no system of accounting that can show it to be a profitable transaction to promote an equipment industry boom that runs a brief course only to collapse when the backlog of deferred maintenance and development has been satisfied. That, historically, has been the trigger which trips the door to the depression phase of the business cycle. No immediate advantage can compensate for the contagious paralysis that infects all business enterprise when major layoffs occur in any major segment. No precautionary measures, self-imposed by business, can be regarded as unduly severe if they can prevent this devastating blight.

2. Financial agencies can and should play a responsible role in regularizing equipment demand. Funds for the purchase of producers' equipment should be offered boldly and at low interest during depression periods, and should progressively tighten as a boom market bids up the price of purchase and installation. Banks and financial houses have excellent facilities for gathering and interpreting market and general economic information. It is good business for them, and for the national economy, to exercise their accepted discretions in a manner that will help to promote economic stability.

3. There now is almost universal recognition of the need for a thorough-going revision of our corporate tax structure to the end that effective incentives may be offered for private capital investment. The possibility of including provisions which would offer special tax concessions to equipment investments made in depression periods is worthy of intensive exploration.

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The fundamental problem here is educational. If all business enterprises in a position to do so were to regularize their equipment expenditures, it would have a tremendously beneficial effect. True, it would accomplish no miracles. For many concerns it is not feasible to schedule equipment buying over a long period. Even those who do schedule it are likely in practice to attain only a relative stability. It must be acknowledged, moreover, that few programs could withstand indefinitely a very deep and prolonged depression such as we had in the thirties. Nevertheless the adoption of stabilization policies where feasible would make a signal contribution both to the restraint of booms and to the mitigation of depressions. Here is something industry can do for itself.

It is easy to disparage such remedies for economic instability as are here proposed on the ground that they are partial only. However, joined with others also partial, they can achieve in combination a solid progress toward the goal of sustained high level employment—progress that is unattainable through economic cure-alls. The road suggested is a slow road, and difficult, but it leads upward.

President, McGraw-Hill Publishing Co., Inc.

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FREIGHT RATES *and* INDUSTRY LOCATION

A SIGNIFICANT decision, announced by the Interstate Commerce Commission last May, will take preliminary effect on the 30th of August. It will eliminate some of the advantage in freight rates which Eastern shippers have enjoyed over shippers of the South and West.

The decision has been enthusiastically hailed as an Emancipation Proclamation for industrial development in the South and West. It has also been roundly condemned as a meddlesome control measure that ignores valid differences in haulage costs, and recklessly blots out one of the important factors in determining the location of American industry.

Cooler appraisals indicate that the net effect of the rate changes will be far less drastic than predicted by the more passionate advocates or adversaries. Nonetheless, it is important for the business world to be informed both upon the principle at issue, and upon the forseeable consequences of the ICC ruling.

What The Decision Calls For

The Commission's order, unless modified, or successfully contested in the courts, will require: (1) the eventual establishment of a single freight classification, or grouping of commodities for rate-making purposes, for application throughout the United States; (2) a single level of *"class rates"*—or rates established for groups of commodities and primarily applying to manufactured and semi-manufactured articles of high value—in the area east of the Rocky Mountains. This level is to be about 15 per cent higher than the present Eastern scale.

Because it will take some time, probably several years, to work out a uniform classification in place of the three major classifications now existing, a preliminary adjustment is provided.

Under this adjustment the existing classifications will remain in effect, but the rates on articles moving on *class rates* will be increased 10 per cent in Eastern or Official Territory—the area east of Lake Michigan and the Mississippi River and north of the Ohio River. On the other hand, the rates will be reduced 10 per cent on articles moving on class rates in the South and West, and on those moving interterritorially.

What The Problem Was

At the present time there are marked differences in the levels of the basic scales of class rates in the five major rate territories—Eastern or Official, Southern, Western Trunk-Line, Southwestern, and Mountain-Pacific. It is difficult to average the levels of rates, but if the level of the class-rate scale in Official Territory is taken as 100, the levels in the other territories may be roughly considered as follows: Southern, 139; Western Trunk-Line, 128, 146, 161, 184 in Zones I, II, III, and IV, respectively; Southwestern, 161; Mountain-Pacific, 166.

These are over-all comparisons. On many individual articles the differences in levels of rates are greater or less than indicated because of offsetting differences in regional classification schemes. In many cases, the use of exceptions to the classifications and of special commodity rates has reduced the regional disparity in rates. In fact, on some articles, particularly on certain low-grade traffic such as logs, pulpwood, bricks, coal, sand and gravel, the South and the West have actually had lower rates than Official Territory. The rate disadvantage of the South and West has been principally on manufactured articles.

The territorial differences in class-rate levels have complicated the problem of constructing rates from a point in one territory to a point in another. Today, such a rate tends to represent a blend of the levels in effect at the place of shipment and at the destination. Thus manufacturers and dealers in a higher-rated territory are likely to see themselves at a disadvantage when they attempt to sell goods in a lower-rated territory against competition located there.

Now, if differences between territorial rate levels are removed, the *inter*territorial freight-rate problem largely disappears. So it is an important question whether such differences are justified. The Commission has found that they are *not* justified either by differences in transportation costs or by

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other valid considerations. From that finding came the order to establish a uniform level of class rates and a single freight classification.

The Decision And The Map Of Industry

What effect will this decision have on the location of industry in the United States; and what effect will it have on the economic development of the East, the South, and the West?

Today, many in the West and South believe that their higher class rates have seriously retarded the industrial development of these areas, and promoted the concentration of manufacturing in Official Territory. They point out that Official Territory has over 50 per cent of the population of the country, had nearly 70 per cent of the persons employed in manufacturing in 1940, and accounted for nearly 73 per cent of the "value added by manufacture" in 1939. Boasts of industrial development in the South, and to some extent in the West, in recent years are accompanied by claims that this would have been greater but for the freight rate structure.

Another point gets into the argument. Official Territory is not only the country's most highly industrialized section, but also its greatest consuming territory. It is the market which nearly all manufacturers desire to reach, particularly when they have a surplus to sell. Here again is occasion for an outcry by producers outside of Official Territory against the consequences of their high rate levels and the levels of interterritorial rates. Under the circumstances it is not strange that the South and West have argued long and volubly for mile-for-mile equality in rates.

Those in Official Territory deny that the South and West have been handicapped by the rate adjustment, but at the same time look with apprehension at the loss of their rate advantage.

What's The Effect?

However, now that the ICC's ruling is about to be put in operation, it is time for the colorful statements of the debating period to give way to a sober appraisal of what the consequences are likely to be.

In the first place, it should be noted that the preliminary adjustment will affect only a small fraction of the traffic. Estimates indicate that only about 4 per cent of the full-carload traffic moves on regular class rates. About 11 per cent moves on exception ratings which are not affected by the preliminary order; and about 85 per cent moves on commodity rates, which were not within the scope of the Commission's decision. The proportion of less-than-carload lot traffic affected is much greater, since a large part of it moves on class rates; however, less-than-carload traffic constitutes less than 1½ per cent of the total tons carried.

The permanent rate structure will probably affect more traffic than the preliminary order since, in the establishment of a uniform classification containing more classes than at present provided, many articles now moving on exception ratings are likely to be brought within the scope of the classification, and the same may be true of some articles moving on commodity rates.

But, even if a large proportion of the traffic were affected by the Commission's order, or if the principle of equality in rate levels is eventually extended to much of the traffic moving on commodity rates, these freight-rate adjustments cannot be expected to revolutionize the pattern of industrial location in the United States.

It seems evident that most industries now found in Official Territory are located there for other advantages than that of a lower level of freight rates, undeniable as such an advantage is. Insofar as that is the case, they have little to fear from equalization of the rate levels. For those which have, indeed, been dependent upon preferential rates and otherwise badly located, the removal of the preference and their consequent shift to some area possessing a real locational advantage would be desirable from the point of view of the national economy.

While the high degree of industrial concentration in Official Territory does not rest on such a flimsy basis as a lower level of class rates, the Commission's decision does remove one existing handicap to the growth and development of the South and West. The new adjustment should permit all sections of the country to develop the industries for which they have natural advantages. It should contribute to a sounder regional specialization than we have heretofore had.

This decision will neither destroy the economy of the industrial East, nor will it, overnight, assure the industrial flowering of the South and West. It constitutes one sound step toward establishing that equality of opportunity for all sections of the country which is essential to a nation that bears the proud title of The *United* States.

President, McGraw-Hill Publishing Co., Inc.

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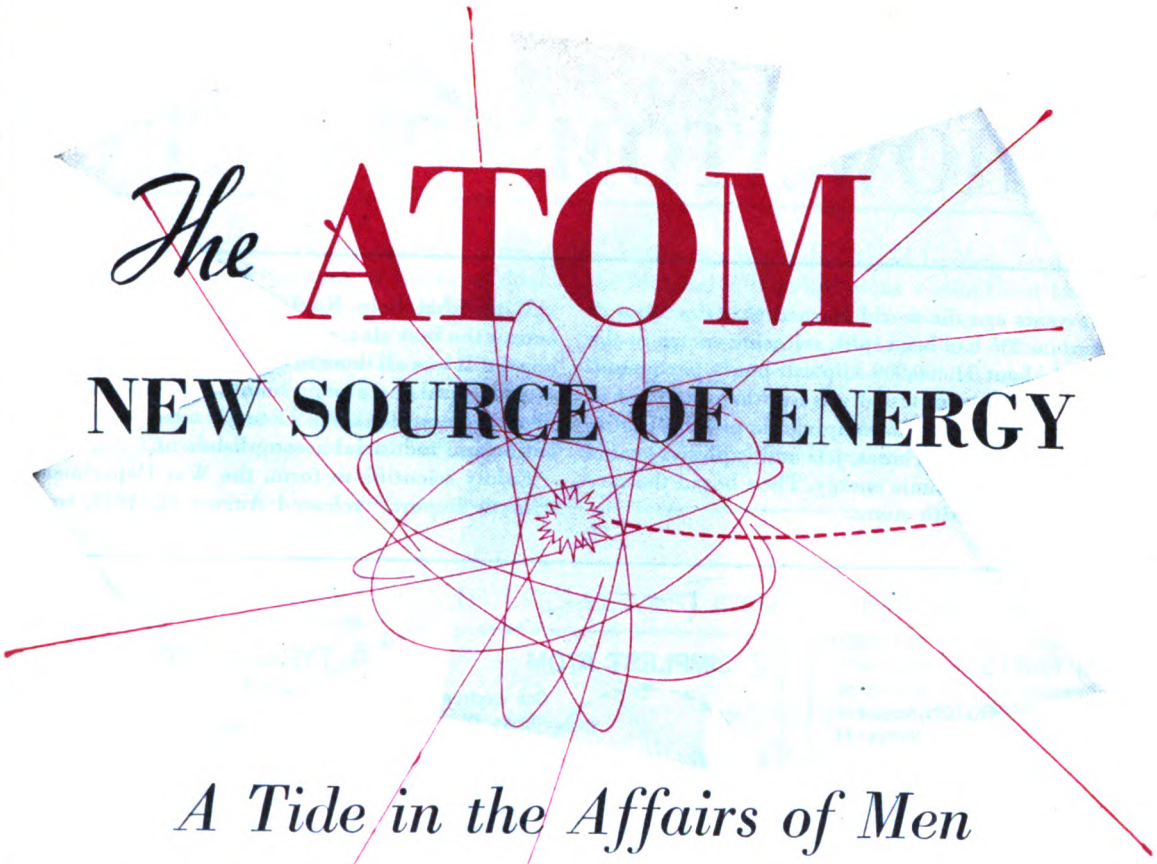

The ATOM
NEW SOURCE OF ENERGY

A Tide in the Affairs of Men

On August 6, 1945, an atomic bomb exploded over the Japanese city, Hiroshima.

Its concussion blasted the city, vaporized the fibre of Japan's will to resist, and flashed across the world a light of such glaring intensity that even blind eyes could glimpse the forked road that is presented to humanity's choice and destiny.

It has been a scant fifty years since Pierre and Marie Curie embarked upon their research with the avowed intent of discovering "how the atoms of the universe are put together". Their work contributed radium to the knowledge and use of mankind, but it marked only a way station upon the awesome quest which they announced and which thousands of scientists have since pursued.

Under the compelling stimulus of war, the first major application of the release of atomic force has been in an instrument that raises by an unimaginable dimension our ability to dole out death. We can be devoutly grateful that the scientific leadership of the Allies, and particularly the industrial strength of the United States, brought to us, rather than to our enemies, priority in the development of this dread weapon. But even in its present infant phase, it is clear that ownership of the principle of the atomic bomb carries a trusteeship of terrifying gravity.

We hold in trust a power that is capable of unraveling the very fabric of our civilization. Equally, it may be susceptible of development as a mighty force for human welfare. But we have proved the destructive use, while the constructive applications are still in the realm of speculation.

Clearly the trust is of a magnitude that transcends national jurisdiction. No walls have ever been built high enough to fence in the spread of **scientific knowledge, and even if we were resolved to forego the harnessing of atomic power for peace, it is hopeless to think that its application for war can be held for long as the monopoly of one, or a small group of nations.**

At one giant stride our scientific and technological development has so far outdistanced our social engineering, that we have no choice but to turn our full powers of creative imagination to control the forces we have unleashed and to bend them to man's use rather than to his destruction.

Since control is not possible without understanding, I have asked several of my editorial colleagues in the McGraw-Hill organization to present on the pages which follow a non-technical but authoritative account of the known facts and implications of atomic power.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

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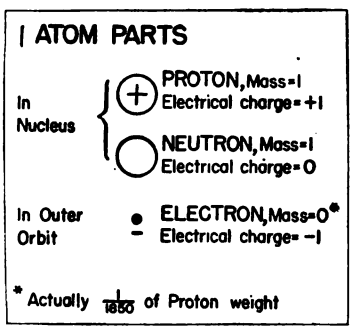
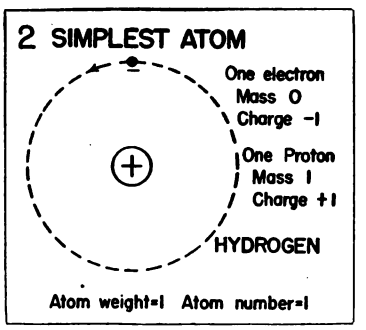
HOW ATOM SPLITTING

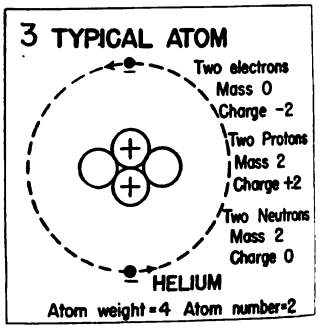
Five years ago the world learned that the atom of Uranium 235 had been split, releasing energy at the rate of about 11,400,000 kilowatt-hours per pound. The whole amount tested was less than the head of a pin, but there was no escaping the possibility that heaters, engines, turbines, jets and explosives could be powered by atomic energy. Then began the race to win the war with atoms.

With what help England could give, America outran the best atom-splitting team Germany could muster. It was all done in silence. From the summer of 1940 until the atomic bomb blasted Hiroshima, black secrecy blanketed history's most amazing scientific and industrial accomplishment.

Coldly scientific in form, the War Department's "Smyth Report," released August 12, 1945, traces



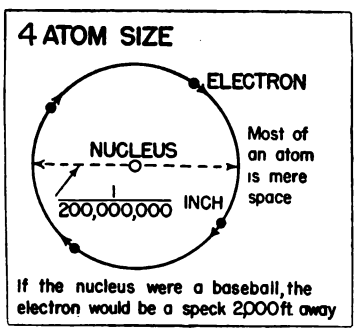


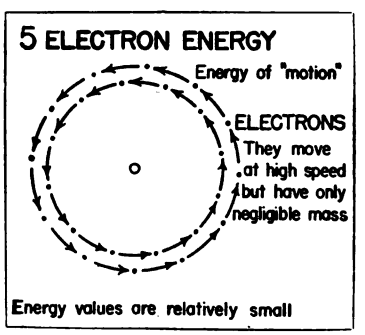


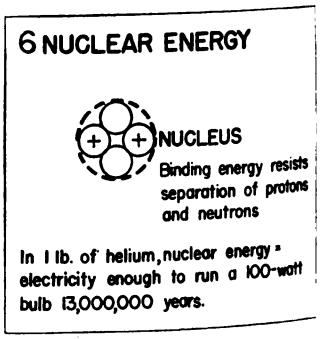
Each of the 92 elements has its own *atom*, yet all atoms are made from the same three pieces, Fig. 1: *proton* (weight 1, electric charge +1), *neutron* (weight 1, charge 0), *electron* (weight 0, charge −1).

Every atom is a tiny "solar system." Its central "sun" has one or more protons, generally neutrons too. The revolving "planets" are electrons, one for each proton in nucleus, because plus and minus must balance in the atom.

The opposite charges attract, but high speed keeps the electrons out in their circular orbits, just as the centrifugal tendency of the revolving earth defies the sun's gravitational pull. All the weight of an atom is in the nucleus, so add the number of protons and neutrons to get the atom's weight. The *atomic number* is equal to the number of protons. The elements are known by their atomic numbers. Thus uranium (92 protons) is element 92.







With only their outermost orbits touching, it would take half a million atoms to span the thickness of a human hair. Yet if one could expand an atom until its outer orbits encircled 100 acres, the nucleus would be no bigger than a baseball. The atom is mostly empty space, Fig. 4, and nuclei are difficult targets; so much so that a neutron bullet fired at a mass of atoms may pass right through without a hit.

The almost weightless speeding electrons, Fig. 5, supply all the energy of chemical reactions (as when coal burns or TNT explodes). Evading all ordinary chemical action, the immensely greater energy bound up in the nucleus, Fig. 6, can be released only by direct hits on the nucleus to break the bonds that hold the protons and neutrons in a tight bundle.

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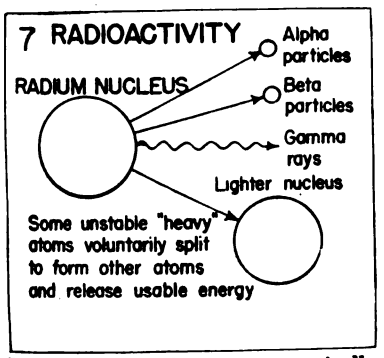
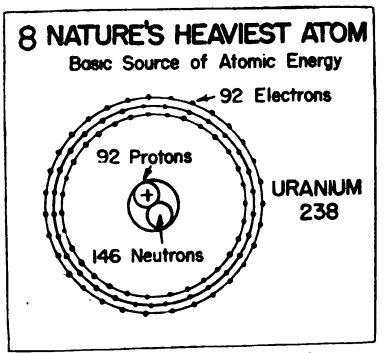
RELEASES ENERGY

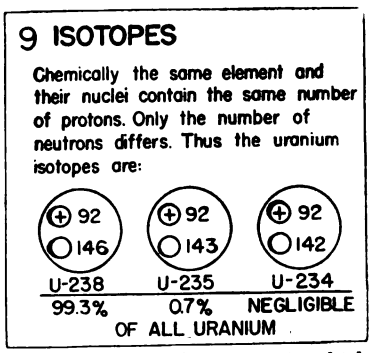
the fantastic course of atomic engineering through the five years of news blackout. It leaves no doubt that only a complete mobilization of America's technical resources could have won this victory in time.

Other writers in other places will unfold the epic story. This presentation leaves no space to reflect the glory of the accomplishment or even to record its history. The aim is more immediately practical — to give the professional and business readers of the McGraw-Hill publications a sound and honest, though non-technical, understanding of this atom-smashing business, so that they will know better what to do about it in their personal and business lives.

Now for step one: learning the shape of atoms and how atom splitting releases energy.

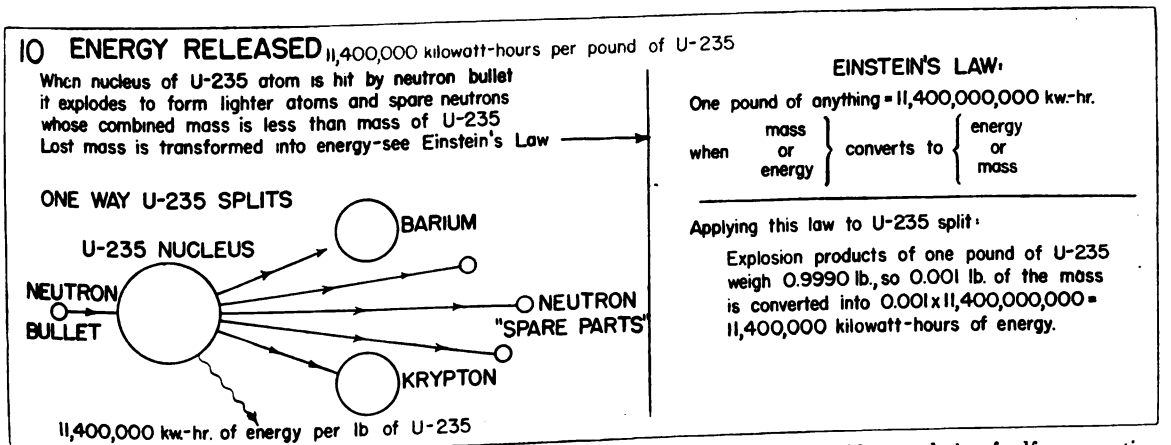






Radium nucleus, Fig. 7, automatically emits particles and energy as it decays to form nuclei of a lighter atom. Most common form of uranium, nature's heaviest atom, is Uranium 238, Fig. 8. This form is not directly useful for energy release, but is important as the raw material for a new synthetic power atom, *plutonium*.

An element may have several *isotopes* — alternate forms with the same number of protons but slightly different numbers of neutrons. Uranium 238 is the isotope in which protons and neutrons total 238 (so atom weight is 238). It is 99.3% of the total weight of pure, natural uranium. The stuff needed for direct atomic-energy release is Uranium 235, only 0.7% of the total weight and very difficult to separate from 238. To put it another way, every pound of energy-giving U-235 comes mixed with a dead load of 140 pounds of relatively inert U-238.



Slow neutron bullet splits Uranium 235 nuclear target, generating two lighter atoms (Fig. 10 shows one possibility) and several free neutrons ready to split other U-235 atoms. The following pages show how the original neutron may be produced and directed and how a chain of self-propagating atomic explosions may sweep through a block of U-235 like a forest fire to release heat energy equivalent to 11,400,000 kilowatt-hours per pound.

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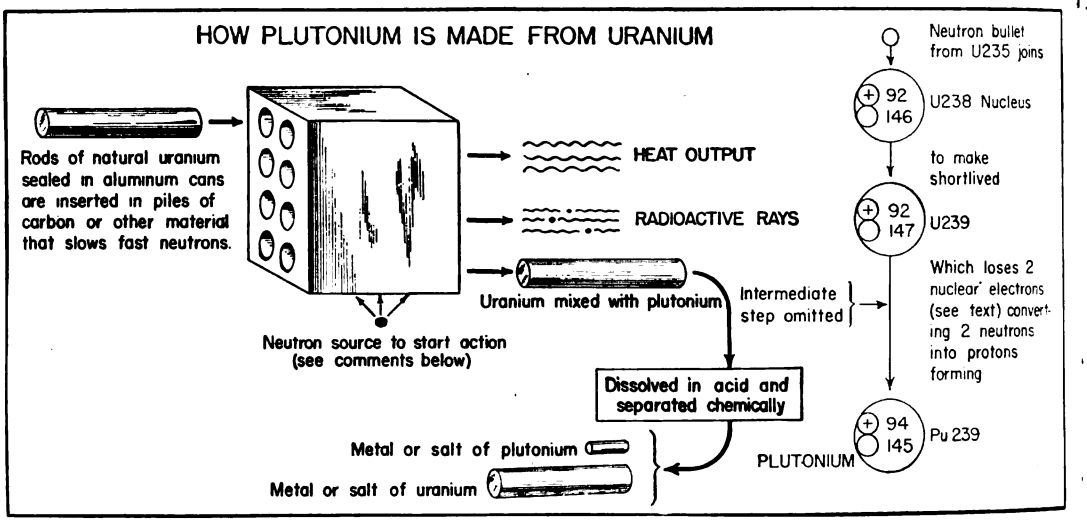
CREATING and ISOLATING

Man-Made Plutonium—U-235 Substitute



We now have two kinds of atoms suitable for energy supply, Uranium 235 and the new man-made element No. 94, plutonium. Uranium, No. 92, has the heaviest atom of any natural element.

The Manhattan Project's plant, on the Columbia River at Hanford, Washington, is the world's greatest atom-making factory. Devoted entirely to the mass production of plutonium atoms, it uses U-238 as the raw material and U-235 as the energy source, intimately mixed in the same proportions as in natural uranium metal.

The production units at Hanford are several huge uranium "piles." Each is a very large block of graphite with holes in which are placed uranium-metal cylinders, sealed in aluminum cans to protect the uranium from corrosion by the cooling water constantly pumped through the pile.

Each pile runs itself, so to speak. Not even the conventionally pictured bits of radium, beryllium and paraffin are needed as a "pilot light" to start operation. There are always enough stray neutrons, or even cosmic rays, to start a chain reaction.

But once started, the design, size and control of the unit must be such that the chain reaction will continue at an even rate — neither die down nor overshoot into an explosion.

To see this picture in atomic terms, consider the fraction of a second in which one million U-235 nuclei are split, producing two million lighter atoms (say, one million of barium and one million of krypton) and between one and three million fast-moving neutron projectiles.

Some of these escape in free flight right through the relatively vast atomic "open spaces." Some are "captured" by the many U-238 nuclei, and others are captured by the impurities. But, on the average, of the one to three million, just one million neutrons must succeed in smashing another million U-235 atoms in the next fraction of a second. Thus, with reproduction rate exactly maintained, life goes on in the atomic-energy pile.

The carbon, one of several possible "moderators," serves to slow down the neutrons without capturing many. The chance of a fast, straight-moving neutron hitting a tiny nucleus is very small, whereas the "slow ball" neutron is likely to be sucked in by the nuclear attraction if it would otherwise be a near miss.

From the practical angle, maintaining a chain reaction requires careful design and good controls. The pile must be slightly larger than actually necessary for a chain reaction (that means scores of tons of material). Controls must be sensitive and dependable. They slow the pile down to the balancing point by sliding in retarders, such as strips of cadmium.

As already noted elsewhere, the energy released is about 11,400,000 kilowatt-hours for each pound of U-235 split. This energy appears first in the high speed of the pieces thrown off by the atomic split, then is converted to sensible heat as collisions slow down these projectiles. The energy is finally removed from the pile in the form of hot air, steam, hot water or other heated fluid in commercial quantity and thermal condition.

Such piles, operated with normal uranium, or with uranium enriched in U-235, would seem to be the primary means by which atomic energy will serve (if ever) as a commercial source of heat and power. Plutonium would be a byproduct, but might under certain conditions add to the energy yield of the pile without the need to separate it from the uranium.

The use of normal uranium in the Hanford pile sounds extremely attractive as a heat source, but has certain economic disabilities. Only a small part of the U-235 is used up before the pile must be shut down to remove the plutonium.

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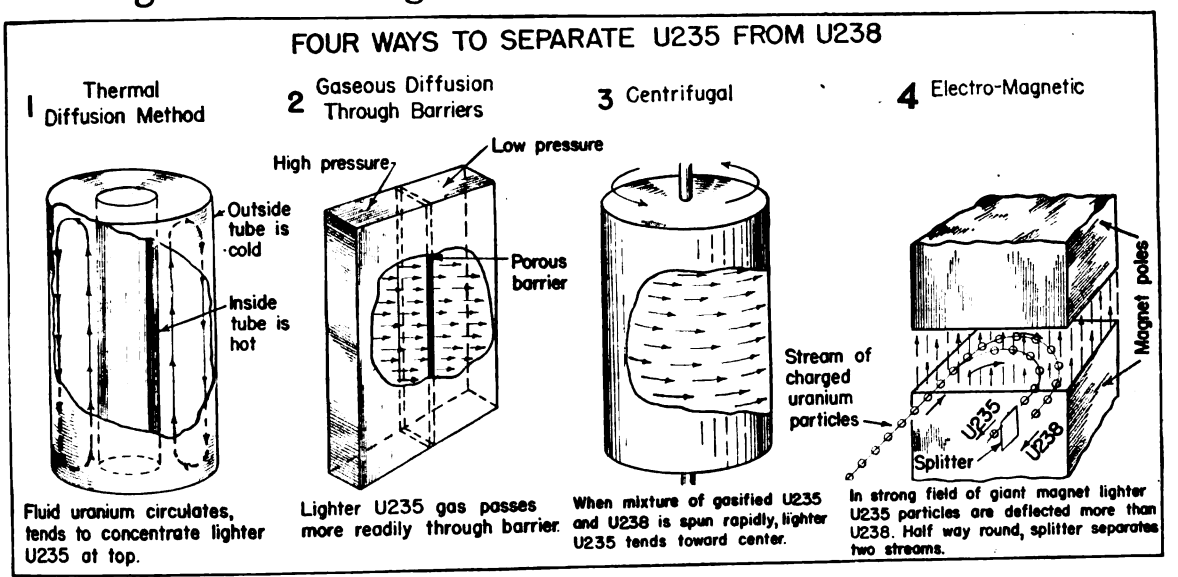
THE HIGH-POWER ATOMS

Isolating U-235 — a Gigantic Task



Many of the uranium ores, including most samples of pitchblende and carnotite, will yield from 1 to 15% metallic uranium. Chemical separation of the metallic "natural" uranium is simple. Whatever the source, natural uranium contains the three isotopes in the constant proportions of 99.3% U-238 and 0.7% U-235, with traces of U-234.

Separating the U-235 from U-238, an operation essential for explosive uses of U-235, and probably important for future commercial controlled-chain piles, has been most difficult. Chemical separation was impossible because U-235 and U-238 are chemically the same.

The only possibility was a separation by physical differences, primarily a one percent difference in weight. The porous barrier and centrifugal methods pictured above required vaporizing a salt of uranium. All the methods shown have been used or tried on the Manhattan Project. All require many stages to achieve a substantial concentration of Uranium 235.

Dollarwise Thoughts on Atomic Energy

Costs mean little in war, but peacetime uses of U-235 and plutonium must pass the dollar test in competition with coal, fuel oil, natural gas, gasoline and electricity.

On the basis of energy costs only, *"all other things being equal,"* the table on the last page of this section shows at what price per pound U-235 would give the same energy cost as conventional energy sources selling at the indicated prices. For such comparisons it is convenient to remember that one pound of U-235 is equal (energy-wise) to about 11,400,000 kilowatt-hours, also to 1500 tons of coal, or 200,000 gallons of gasoline.

Fuel engineers understand the limitations of such oversimplified comparisons. Others should be warned that "all other things" are never equal. With this thought in mind, reconsider the uranium piles operated at Hanford to produce plutonium. These use U-235 in the cheapest form, say about $1400 per lb., assuming purified normal uranium at $10 per lb. (140 lb. of uranium contains one pound of U-235.)

If this were the whole story, coal would have to sell for a dollar a ton to break even with U-235 as a water heater. However, the pile using normal uranium must be immense to hold its own in a chain reaction. More important, the accumulating fission products "poison" the reaction after only a small part of the U-235 has been used up. Then the uranium cylinders must be removed for plutonium recovery. Finally, it has not yet been found possible to operate the normal-uranium piles at high enough temperatures for practical power production.

If we go to the other extreme and build a small pile, using concentrated U-235, we shall run into excessive material costs, perhaps several times the $52,000 per lb. set down in the table as the equivalent of 20-cent gasoline.

Something between the two extremes is likely to prove the most economical — perhaps a pile operating on a U-235 concentration between 1 and 10%.

The engineer of the "atomic-power age" must know the price of Uranium 235 *in various concentrations* and the characteristics of piles suited to them. No such information is yet available. He must also watch the danger from radio-activity; the requirements for radiation shields; explosion hazards, etc.

CONTINUED ON NEXT PAGE

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WHAT TO EXPECT

Before discussion of possible and probable future applications of atomic energy to the arts of peace, the atomic bombs should have consideration. We may assume that these bombs contained from two to 200 lb. of either U-235 or plutonium, or both. No more precise information is available.

Details of the bomb design have been completely suppressed, but the following basic considerations are stated or implied in the Smyth Report:

The explosive in a bomb must be highly concentrated U-235 or plutonium. Since slow neutrons could not produce a satisfactory explosion, the neutron retarder or *moderator*, is minimized. This, in turn, requires a U-235 mass so large that the escape of neutrons without hitting nuclei will not be excessive. For every 1000 atoms hit, the neutrons produced must split more than 1000 new atoms, so that the reaction will proceed rapidly in an expanding chain, as sketched below.

There can be little leeway in the size of the explosive charge. For a given shape there is a certain "critical" weight of material. If this is exceeded the bomb explodes instantly. If the weight of charge is less than the critical, it cannot be made to explode.

Therefore, the critical mass must be created at the moment of explosion.

The Smyth Report suggests that this can be accomplished by breaking down the charge into two or more well-separated parts, each having less than the critical mass. At the appointed moment these could be brought together within the bomb to create a supercritical mass, which would then explode automatically.

CLAIMS LIKE THESE ARE NOT JUSTIFIED

1. Pretty soon no more coal will be mined except as a raw material for chemical manufacture.

2. In a few years a tiny bit of uranium, built in at the factory, will drive your car for life through an engine no bigger than your fist.

3. All the big central stations will soon be running on atomic power.

4. Cheap atomic energy will enormously reduce the price of power.

Peacetime Applications

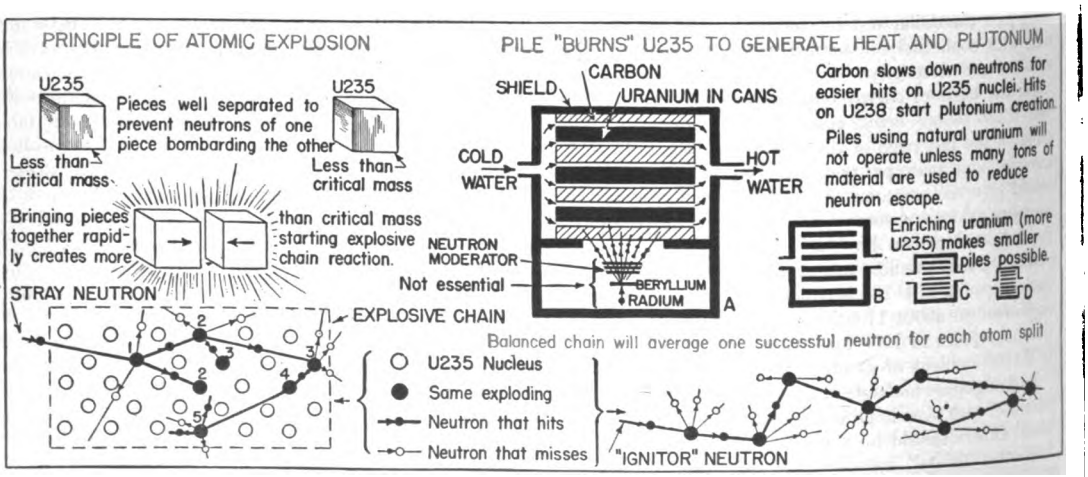
Except possibly for superblasting operations, uncontrolled explosive reactions cannot be permitted in the peacetime use of atomic energy. This means that the quantity of U-235 assembled in any one spot must always be kept well below the critical weight to avoid spontaneous explosion.

Depending on the particular application, the most desirable concentration of U-235 may range anywhere from the 0.7% in normal uranium up to 100%, with the probability that many industrial applications will find the greatest economy in concentrations between 1% and 15%.

This matter of the degree of concentration of U-235 has received little public attention, yet nothing could be of greater practical importance. To make this point clear, consider the two extremes, 0.7% of U-235 and 100% of U-235, respectively.

The Hanford pile, using normal uranium (0.7% U-235) with carbon moderator, must be very large to work at all. It is inefficient in the sense that it must be shut down after a small part of the U-235 has been consumed. It cannot operate at high temperatures.

Its great advantage as a heat producer is the fact that its U-235 is bought at the lowest possible price. If



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FROM ATOMIC ENERGY

...BUT REMEMBER THESE FACTS

1. The large-scale, controlled release of heat energy from U-235 has been fully demonstrated.

2. Beyond question, this energy could be applied directly for heating water and air, and making steam.

3. Such heat, in turn, could be applied directly, or converted into mechanical power or electricity by conventional steam turbines and gas turbines.

4. If and when U-235 in concentrations up to 10% costs less than $25,000 per lb., it may find applications, but will compete, at first, with premium fuels rather than coal.

purified normal uranium sells for, say, $10.00 per lb., the price of 140 lb. (containing one lb. of U-235) will be only $1400. This would be a very favorable price if the pile could operate efficiently with the 0.7% U-235.

Concentrating the U-235 to 100% would permit a much more compact and convenient pile — perhaps little more than small pieces of U-235, encased in aluminum to ward off corrosion, and immersed in a tank of water; this should convert the water into steam at a regulated rate.

In large part, the control would be inherent. The water as a moderator would keep the chain going, but if the reaction got too violent, the resulting higher superheating of the steam would decrease the moderator effect and thereby hold the reaction in check. Yet even if all this comes true the cost of concentrated U-235 in the near future will be many times $10,000 per lb.

Running up the concentration only a few percent above that in normal uranium may prove to be the way to get reasonable pile size and good efficiency without incurring exorbitant concentration costs.

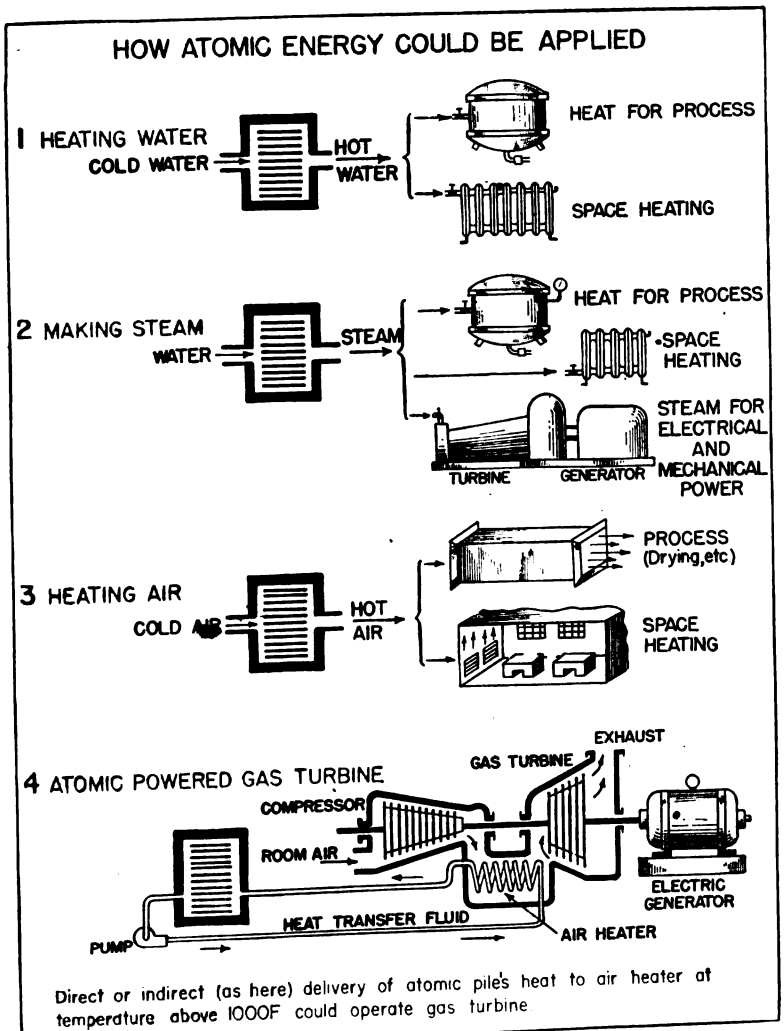
When atomic energy is applied, the starting point is heat, picked up by water, air or a special heat-transfer fluid. Intermediate heat transfer fluids may be essential in certain applications (space heating and service water, for example) where people must be protected from injury by radioactivity.

The intermediate heat-transfer fluid shown for the gas turbine would, of course, have to operate at temperatures up to 1200 F. There seems to be no basic reason why the pile itself could not be built inside the compressed-air receiver, discharging its heat directly to the compressed air.

With rather high concentration of U-235, this arrangement might be suitable for large airplane drive if excessive weight of radiation shields could be avoided.

Also, presumably, rockets and planes of the "buzzbomb" type could be powered by atomic heat delivered to the air of the jet steadily, not in puffs.

The sketches stress direct applica-



Direct or indirect (as here) delivery of atomic pile's heat to air heater at temperature above 1000F could operate gas turbine

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THESE THINGS MIGHT RESTRICT USE OF ATOMIC ENERGY

1. Ineffectiveness of large piles using normal U-235 concentration
2. High cost of concentrated U-235 for smaller, more effective piles
3. Danger from radioactivity
4. Weight and cost of shielding against radiation
5. Explosion hazard
6. Possible short supply of uranium
7. Governmental restrictions on atomic-energy materials

tions of hot air, steam and hot water to process and space heating. This emphasis is justified by the often overlooked fact that such applications of heat have many times the total energy value of all the electricity generated in the United States for all purposes.

There has been much popular speculation regarding the type of engines required for atomic-power generation. The answer is simple. Present engines, steam turbines and gas turbines can be used with little or no change. This, of course, does not rule out the possible discovery of specialized engines for atomic power, or even direct production of electricity from atomic energy.

In the long run the implications of atomic power are staggering for both war and peace. However, popular writers on the subject have undoubtedly created unreasonable hopes in the minds of readers — for example, the expectation that in two or three years the Detroit builders will market cars with built-in "lifetime" slugs of U-235 and "fist-sized" engines.

Yet it seems fairly safe to predict that atomic energy will find some commercial applications within the next five or ten years, first, probably, as a premium fuel like aviation gasoline, worth a fancy price for specialized applications where low weight or some other characteristic is important.

As the cost of concentrating U-235 is reduced and application efficiencies improved, atomic energy may compete with cheaper fuels, perhaps ultimately with coal.

Important non-power applications of atomic energy may well include the ultra-high-temperature processing and fabricating of materials — also, modern "alchemy": building and rebuilding atoms to create new elements and to produce old elements at lower costs.

Radioactivity obtained directly or indirectly from artificial atom-splitting should find many important medical and industrial applications.

Turning back to ordinary power applications, we must avoid the temptation to overstress the economic importance of lower-cost power fuel. Fuel cost is only about 17% of the gross receipts of the electric utilities. Here's another way to put it: If, after allowing for transmission losses, one kilowatt-hour delivered to the consumer from modern plants represents a coal consumption of 1.5 lb., and if the coal costs $5.00 per ton cancellation of the coal bill could not save more than ⅜ of a cent per killowatt-hour. And atomic fuel will certainly not be free.

Performance of the atomic bomb is a monument to the scientists who unlocked the secrets of the atom and suggested the basic technique of making plutonium and concentrating U-235.

From there on, the job was at least 50% engineering. The various big plants of the Manhattan Project are vast assemblages of pipes, tanks, boilers, valves, instruments and controls, installed and operated by engineers, largely designed by engineers. From now on, the speed with which atomic power becomes practical will depend on the effectiveness of the engineer-scientist team.

It is possible, of course, that national controls may completely upset the entire technical and economic pattern of this discussion. For reasons of national security the government may decide to control or restrict atomic-power materials, plants and operations in ways not yet determined.

U-235 COULD COMPETE AT THESE PRICES
other things being equal

Common fuel	*Assumed prices*	*Comparable prices for Uranium 235, dollars per pound (nearest thousand)*
COAL (13,000 B.t.u.)	$6 per ton	$9,000
	$12 per ton	$18,000
	$15 per ton	$23,000
FUEL OIL (150,000 B.t.u. gal.)	2¢ per gal.	$5,000
	4¢ per gal.	$10,000
	8¢ per gal.	$20,000
CITY GAS (500 B.t.u.)	50¢ per 1000 cu. ft.	$39,000
	$1 per 1000 cu. ft.	$78,000
NATURAL GAS (1000 B.t.u.)	25¢ per 1000 cu. ft.	$10,000
	50¢ per 1000 cu. ft.	$20,000
	$1 per 1000 cu. ft.	$40,000
GASOLINE (150,000 B.t.u. gal.)	10¢ per gal.	$26,000
	20¢ per gal.	$52,000
	30¢ per gal.	$78,000

BUT

Note that "other things" are never equal. U-235 in normal uranium form is by far the cheapest, but involves use of excessively large and inefficient "piles." The unit cost of the U-235 in enriched mixtures increases with the degree of enrichment. Over-all cost comparisons can be made only for a specified concentration of U-235 and for apparatus suitable for that particular concentration. Possible explosion danger and need to protect personnel against radiation are other important considerations.

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LABOR *and* MANAGEMENT MEET— *for* PEACE *or* CIVIL WAR?

The prospect of a knock-down and drag-out fight in the automobile industry does not augur well for the reconversion outlook, which upon every other score is bright. Any widespread outbreak of the type of industrial warfare which now threatens will disrupt, more thoroughly than anything else on the horizon, an orderly transition to a peacetime economy.

It is doubly unfortunate that there should be a general tightening of union and company battle lines upon the eve of the Labor-Management Conference, which on November 5th will convene at President Truman's direction for the purpose of "working out by agreement means to minimize labor disputes." If the current work stoppages occasioned by industrial conflicts should increase rather than diminish between now and November first, the Conference atmosphere hardly promises to be favorable to a dispassionate examination of basic issues.

Yet the shadow of the threatened industrial storm that hangs over the Conference only serves to emphasize the importance of reaching satisfactory agreement upon two problems with which such a Conference might deal. The first is that of determining what machinery shall be used for settling disputes upon which employers and workers have reached an impasse. The second, and more far-reaching, is that of arriving at some common understanding upon the major issues which commonly lead to irreconcilable disputes.

Settlement of Wartime Disputes by the War Labor Board

During the war the first problem was handled largely by machinery centered in the National War Labor Board. Supported by general adherence to patriotic pledges by labor leaders and employers not to resort to the use of economic force against each other during wartime, and backed up on rare occasion by use of the President's power to seize plants for war purposes when its orders were not obeyed, the Board managed, by what amounted to compulsory arbitration, to settle the nation's wartime labor disputes with relatively little economic loss.

But it can scarcely be claimed that the War Labor Board did much to resolve the issues from which disputes grow. Indeed, the fact that it was available to issue orders in cases which the Secretary of Labor certified as likely to "lead to substantial interference with the war effort", resulted in the conversion into full fledged disputes of many disagreements which would otherwise have been settled at a local level in the course of collective bargaining. Meanwhile, local collective bargaining machinery which should have been doing most of this work was neglected, and will need thorough reconditioning even to be brought back to its prewar level of effectiveness.

With V-J Day came an abrupt change in the status of the War Labor Board. One of its main props, labor's "no strike pledge", was promptly withdrawn. It could no longer rely on the President to use his power to seize plants for war purposes to force obedience to its orders. Consequently the Board agreed that it would accept new cases only if both parties to the dispute stipulated in advance that they would abide by the Board's findings, that it would clear its dockets of old cases as rapidly as possible, and that it would then go out of business, leaving to the Labor-Management Conference the question of what should take its place in the postwar period.

What Shall Take the War Labor Board's Place?

The immediate and pressing task of the Labor-Management Conference is to agree upon machinery for settling industrial disputes in the peacetime economy.

Neither management nor labor wants the continuation of compulsory arbitration to which they submitted as a necessary war measure. But it must be clear to everyone that if any substantial proportion of the disputes that inevitably arise are settled by resort to strikes and lockouts, economic anarchy will result. Not only will it be impossible to achieve the high levels of output and employment that have been set as postwar goals, but it is questionable whether our economy could survive. The only alternative to compulsory arbitration under government auspices is for management and labor to demonstrate their ability to effect a peaceable resolution of their differences without it.

The most obvious need is to set up local machinery at the grass roots where disputes originate. That is where most of them should be settled by local negotiation and, when that fails, through voluntary submission to mediation or arbitration under terms of reference to which the parties agree. Many issues, which at plant level are relatively simple in character, are blown up to formidable dimension and complexity when they are passed along

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the line for decision in Washington. The centralizing process is one that frightens everyone connected with it because it focuses attention upon the possible importance of precedents established by a decision, rather than upon resolving satisfactorily the particular dispute at hand.

Unquestionably, some Federal machinery must be provided which may be called upon in cases where the size or implications of a threatened dispute clearly run beyond local jurisdiction. That will mean the thorough revamping of conciliation and mediation machinery which exists, but which has grown rusty through disuse while compulsory arbitration was the order of the day.

At least, this involves a complete overhauling of the United States Conciliation Service with a noteworthy strengthening of its personnel. There may be wisdom also in recently advanced suggestions for the creation of a board of arbitration to act in cases voluntarily submitted by the parties concerned, and for boards of inquiry to make reports upon the merits of disputes in which the public interest is concerned. But there is valid ground for questioning what appears to be the common assumption that such machinery should be located in the Department of Labor. It belongs neither there nor in the Department of Commerce. For the work which such agencies are called upon to perform, both the appearance and fact of complete impartiality are essential to effective performance. Assurance of impartiality will not be fostered by placing them in a department specifically charged by Congress with the task of advancing the interests of wage workers.

Resolving the Issues Over Which Disputes Arise

It may be, as many think, that the forthcoming Labor-Management Conference cannot effectively handle any problems beyond the procedural ones suggested above. If that is true, its agenda probably should be restricted to planning the reconstitution of collective-bargaining and dispute-settlement machinery, in view of the urgent need for putting it in working order.

But either in this Conference, or in subsequent ones, there will have to be an attempt to reach a reasonable measure of labor-management accord upon certain basic issues over which most industrial disputes originate. The best of machinery can be swamped if disputes are generated in ever-increasing number.

Most important of such issues is that of the fair determination of wages. There is clear need for reaching agreements at least upon the major factors on which such determination should rest. It seems evident that if we are ever to hope to reach the high levels set and generally accepted as postwar goals, we must harness economic incentives to promote production efficiency. That means that workers, as well as management, must be given a genuine stake in increased productivity. No universal formula is possible, but we should be able to agree upon general principles for dividing returns derived from improved performance in output between workers and investors, and consumers in the form of lowered prices.

Again, since unionism is here to stay, general acceptance by management of the principle of collective bargaining would save innumerable disputes which are concerned more with the method of negotiation than with the concession sought. Few in management still question the validity of the collective bargaining process as such, but there are many matters to be resolved of which the question of the open shop, the union shop, or the closed shop is merely a conspicuous example, upon which there is wide divergence of conviction between and within labor and management groups.

On the management side, there is sincere concern about the intent or ability of union leaders to exercise responsible control that assures compliance with contractual obligations. Wild-cat strikes are of sufficiently frequent occurrence to give substance to this distrust, and union discipline seldom has been administered in a decisive or effective fashion. The prospective rivalry of three competing labor organizations of national scope gives management little confidence that a bargain made and kept in good faith with any one of them provides assurance against work stoppages.

All of these matters, and many others, need thrashing out between management and labor, with the view of arriving at as large a measure of specific and detailed agreement as can be achieved. The greater the area of such agreement, the smaller will be the area for disputes that must be handled by settlement machinery, or put to the final test of force.

Peace or Civil War in Industry

The Labor-Management Conference is of major importance to national welfare. It is important even if it restricts its objectives to the procedural problem of how industrial disputes are to be handled.

It can make an even larger contribution if it lays the groundwork for an attempt to reach working agreements upon such policy issues as have been cited above.

Neither management nor labor can afford to lend anything less than their best intelligence and effort to an attempt to arrive at common understanding. Success will mean that we have a genuine chance of reaching new levels of economic well-being. Failure will mean industrial civil war, in which the casualties will be high. One almost certain casualty of such a war will be the principle of collective bargaining, since the Government can scarcely refrain from establishing compulsory arbitration if sufficient breakdown occurs.

It is to the vital interest of both management and labor to demonstrate that they can responsibly control themselves.

President McGraw-Hill Publishing Co., Inc.

THIS IS THE 40TH OF A SERIES

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THE GERMAN ECONOMIC PEACE HARD, SOFT... or WORKABLE?

IT is not surprising that difficulties are being encountered in spelling out the detailed terms of the German economic settlement.

The problem is exceedingly complex. The German economy is more or less inextricably bound up with the economy of continental Europe. Before the war that area—excluding the United Kingdom, Ireland and Russia—accounted for approximately one-fourth of the world's production, and for more than thirty-five per cent of world import and export trade. Germany's production constituted almost one-third of the output of continental Europe. It is obvious that the decisions we make now concerning the future German economy will exert profound influence not only upon the economy of Europe but also upon that of the world. It is clearly not practicable to plan for an expanding world economy unless provision is made for Europe generally to share in the development.

Despite the magnitude and complexity of the problems involved, it is crucial that we and our Allies come to swift and decisive agreement. Such agreement is important both to world economic reconstruction, and as a demonstration that those who won the war can reach accord on the terms of world economic rehabilitation.

We shall accomplish little if we continue to debate in terms of *adjectives*. Yet most of the public discussion to date has centered around whether or not the economic settlement with Germany should be *hard* or *soft*. To make progress we must focus instead upon *objectives*. A good program is one that will promote our objectives—a bad program is one that will not.

What Are We Trying To Accomplish?

Upon the economic objectives of the German peace settlement there is little fundamental debate. This is demonstrated by reference to a number of documents of recent release—the United States Directive to General Eisenhower of April 1945, the Report of the Tripartite Conference at Berlin of July, the Report of the American Advisors to the Office of Military Government of September. The latter document stresses fundamental difficulties in developing a practical program for carrying out the objectives of the other two, but it does not question their formulation of aims.

What are the objectives that we are seeking to forward:

1. The disarmament of Germany.

2. The elimination of German industries devoted primarily to armament production.

3. The assessment of reparations to compensate those nations which have suffered losses from German aggression through direct war destruction and through the German policy of confiscating industrial equipment to her own use.

How Far Are We Agreed on Procedure?

There is also a wide measure of agreement upon detailed procedure for carrying out these objectives. No one, of course, questions the policy of confiscating German arms. Equally, there is agreement that German industry devoted directly to the production of war equipment should be confiscated or destroyed, and that control measures should be instituted and sustained to prevent her from reconstituting such industries in the future. Since it is not practicable to prevent aircraft production and shipbuilding from being diverted to military use, these industries are included in the armament category. And similar reasoning generally extends the list of prohibited industries to ball bearings and abrasives.

There is an additional category of German production which all of the Allied powers agree should be uprooted and permanently barred. It embraces all economic activity which prewar Germany cultivated on an uneconomic basis through subsidy and other protection for the prime purpose of developing a self-sustaining economy to support aggressive war.

The major elements in this category are not difficult to define. A great German industry for the synthetic production of gasoline and other oil products from coal never operated upon an economic basis. The cost of such fuel products to prewar Germany averaged almost four times what it would have cost her to buy petroleum products in the world market. It is doubtful whether these plants could be operated postwar at a cost much below three times the world market price for competing petroleum products.

A similar situation applies to German synthetic rubber production. In an attempt to free herself at least partially from dependence upon supply lines, she produced synthetic rubber at a cost at least double the world market purchase price. Similarly, she protected or otherwise subsidized a considerable agricultural production, particularly in grains, for which her lands were so ill suited that Germans had to pay for German-grown wheat from three to four times the world market price.

These are merely outstanding examples. The maintenance of such activities in Germany constituted a drain upon the German economy rather than an advantage other than that of preserving a self-sufficiency necessary for war. Hence their elimination is clearly indicated, and generally subscribed to, though the job of defining a complete list is far from easy.

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What Is The Area of Dispute?

Unfortunately, this total catalogue of agreed-upon measures is not sufficient to provide either adequate security against a resurgence of German militarism or satisfactory restitution to her European neighbors for Germany's ruthless destruction of their industrial plant and equipment. To serve these two ends it is necessary to cut down the margin of German dominance in heavy industry—in steel, in electric power, in machine tools, and other industrial equipment. Unless such steps are taken, Germany will emerge from the war with sufficient industrial power to provide a continuing and perhaps uncontrollable military threat; and we should be perpetuating a dominance that was developed, as a matter of German strategy, far beyond the requirements of her civilian domestic markets or the export potentials of normal trade.

German steel capacity was built to a wartime peak of twenty-four million tons a year. Before the war she had accumulated a store of machine tools greater than that of the United States, and her present stock of some four or five million tons of such tools is second only to ours. There is little debate over the necessity and justice of cutting down the margin of German dominance in heavy industry, particularly since it was built to its current levels through aggressive economic warfare to serve as an instrument of actual warfare. It is recognized, too, that in this sector of the German economy will be found the most useful reparations in kind for the countries damaged by German aggression.

The question is how much heavy industry and electric power equipment should be taken from Germany and transferred to others. The Russians, having experienced colossal war damage, are demanding very severe assessments. They talk of reducing postwar German steel capacity to three million tons annually.

The United States inclines to assessments in this field of less extreme dimension—we have suggested leaving in Germany an annual steel capacity of from seven to ten million tons. We naturally are concerned lest action be taken that will cause a complete breakdown of the German economy. If this should happen while we maintain occupational forces there, we should feel responsible for seeing that the Germans within our jurisdiction are provided with at least the means for subsistence. Furthermore, both we and the British know that in the long run our peoples will not support control measures over Germany which go beyond our concepts of reasonable fairness consistent with security requirements.

It is no part of our intention, as has been suggested by some, to provide for a German economy that will serve as a buffer against Russian expansion. We know, however, that our weakest course would be to commit ourselves now to continuing control measures which our people would later repudiate as falling outside democratic concepts of justice. On this issue we cannot, and should not, compromise.

How Can We Resolve Our Differences?

The best chance for resolving the differences which have appeared between the Russian position on the one hand and the American and the British position on the other lies in making a sharper distinction than has appeared in current discussion between long-term and short-term control decisions. All of us are agreed upon the policy of wiping out German military production and that part of German economic activity which has been run at economic loss to provide for a national self-sufficiency useful only for war purposes. But we are unwilling to enter into long-term commitments for holding down those parts of the German economy that do not constitute a war threat. That would unduly penalize future generations of Germans and drag down the whole economy of continental Europe.

It should be possible to reach agreement that measures for cutting down German heavy industries and power-generating facilities are immediate measures, and that no attempt will be made to sustain such controls over an extended period. If part of the German establishment in these fields is transferred to countries whose manufacturing resources have been damaged by German aggression, it can serve the purpose of effecting a reasonable balance without destroying utterly incentives for a new generation of Germans to improve by peaceful methods their status in a peacetime world.

Such a program is consistent with the concept of building a healthy and balanced European economy in which general economic interdependence provides one of the essential safeguards against a resurgence of German militarism. We must still face the problem of agreeing upon how far the non-armament segments of German industry can be cut back at the present juncture without leading to disastrous breakdown with its resultant chaos. Such definition, though formidably difficult, should not be beyond the capacities of the nations whose combined might brought victory, and who have the strongest of incentives for devising a lasting peace.

The key to agreement lies in each of us doing his best to understand the position of the other. Russia must recognize that we cannot get our people to subscribe to the permanent repression of a European economy which would deny to millions of people any hope of normal economic betterment. We should try to understand Russia's conviction that she is entitled immediately to reimburse herself for her war losses by drawing upon the German industrial establishment that still exists. It will help to resolve our differences if we separate in our thinking steps that require permanent controls from those which are merely temporary expedients.

Neither of us will be forwarding our ultimate and common objectives if we impose controls that blight the development of so large and important a segment of the world as continental Europe. In such a blight lies the germ of a Third World War.

President, McGraw-Hill Publishing Co., Inc.

THIS IS THE 41ST OF A SERIES

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CONTROLLED ATOMS or CONTROLLED LIVES

SINCE August 6th when the first atomic bomb was released over Hiroshima, the American people have been subjected to a continuous barrage of pronouncements on the use and control of atomic energy. Some of this comment has been strident, and much of it conflicting. A considerable portion of it has been of sincere and constructive excellence.

It has not been easy to separate the wise counsel from the merely noisy, and it is small wonder that the minds of many are troubled and confused.

However, the sheer mass of discussion poured into press and microphone has awakened us all to the gravity of the issue. In terms of any problem on which Americans ever have been called to exercise a judgment—This is It!

Even the dullest now recognizes that atomic weapons hang over modern civilization like the Sword of Damocles, and understands in some measure how fragile and taut is the hair of political balance that holds it suspended.

From this point on, we need the coolest and most carefully considered judgment that can be brought to bear. Discussion highly charged with emotionalism will but increase the tensions both at home and abroad, and render wholly insoluble a delicately intricate problem.

What Is The Problem?

The major outlines of that problem now are coming into focus in understandable terms:

1. The scientists have opened up a new and virtually unlimited storehouse of energy, and the engineers have discovered how to turn it into a military explosive incomparably more powerful than any we have known. We know that this energy may also be used to produce heat for useful power, and we suspect that the radioactive substances produced by the process in hitherto unimagined quantity may also have medical, industrial, and other constructive applications.

2. Terrifying as have been the demonstrations of the atomic bomb thus far, we know that they are as nothing in comparison with its potential destructiveness. The explosive force of individual bombs can be increased tremendously, and means for their effective delivery to predetermined targets in wholesale quantity already are at hand. The experts tell us that no practicable means of interception can be devised, and that reprisal in kind probably will be the only answer to an enemy attack with atomic weapons.

3. So far as we can see now, even successful retaliation would be at best an answer of hollow effect. Any two nations each having wholesale stock-piles of bombs could accomplish the practical destruction of each other. Since a first treacherous blow might well constitute an enormous advantage, a nation actuated by a ruthless urge to conquest or revenge might have the best chance of survival. But since the widest possible dispersal of bombs and launching units would be dictated by the strategy of atomic weapons, it is doubtful that one nation could destroy another without itself suffering destruction. On both sides the major centers of population could be wiped out, and the nation of least concentrated industrialization and commerce would suffer least. However, no one can be sure that the concentrated explosion of as many as 20 thousand atomic bombs would not poison the atmosphere of the world to an extent that would be fatal to great masses of population, not only within the country bombarded, but perhaps in the country which launched them.

4. The problem is further complicated because, so far as we know now, any large-scale commercial use of atomic energy as a power source is more or less inextricably linked to a potential military use. It is true that, if atomic power becomes economically feasible (which is by no means certain for a long time to come), it would require only low-grade concentrates of fissionable material, which would need further elaborate and costly processing before reaching explosive potential. But the process of producing such low-grade concentrates constitutes perhaps two-thirds of the industrial effort required to make effective bombs. It follows, then, that if nations were to equip themselves to produce large quantities of low-grade concentrates for power generation, the effort required to develop large-scale bomb production would be materially reduced. Moreover, the maintenance of an effective inspection to police agreements not to produce bombs might be forbiddingly difficult if atomic power generation were allowed.

5. In addition to the major problem posed by the use of atomic bombs in international war, any nation which produces or possesses such bombs, or the fissionable materials with which they are loaded, faces still another in the danger of their falling under the control of paranoid elements in its own population.

What Are We Going To Do About It?

We face the hard fact that we have produced a weapon capable of destroying whole nations—perhaps even the whole world. Although we were importantly aided in its development by the nationals of other countries, we, together with Great Britain and Canada, now must take the initiative in deciding what shall be done with it. We have only two choices. We can try to keep this weapon as a monopoly of our own, or we can try to place it under broad international control.

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Can We Keep It To Ourselves?

If we know one certain fact about the atomic bomb, it is that it cannot long be held as a monopoly of those nations which produced it.

If Nazi Germany had succeeded in developing the weapon first, it probably would have attempted to achieve world dominion, with utter destruction as an alternative. Such a course is not within our range of choice. It violates every principle for which we stand.

Much reckless nonsense has been uttered concerning the inability of other nations to master the scientific, engineering, and industrial problems involved. It is the virtually unanimous opinion of those who worked on the project that several nations today are fully equipped in science, engineering, and industrial organization to produce atomic bombs and to provide the means for launching them. At least one of these nations, Russia, has also access to an ample supply of the necessary raw materials. The only debate is over whether it would take three, or five, or ten years for her to marshal her resources to produce bombs in multiple thousands. Once such an atomic race were on, we have no reason to believe that Russia might not divert more resources to the task than we ourselves should be willing to put into it.

Additional nonsense is talked as to how we might attempt to cope with the problem of living in a world in which mutually suspicious or hostile nations faced each other, with stores of atomic weapons on both sides. We hear talk of dispersing our cities and even of moving underground. No one has seriously reckoned the difficulty or the cost of following such counsel of despair. Still less has anyone appraised the neurotic effect upon men's minds of living by any such preposterous formula, under continuously mounting tension day after day, and year after year.

Certainly, if we could find no way to prevent the competitive production of atomic weapons, we should be driven at least to the selective dispersion of our bomb-launching facilities, of certain key industrial establishments, and of our centers of government and governing personnel. We should be forced, also, to change our traditional requirement that only Congress can commit us to active war. We should be forced to organize ourselves as a police or military state, with our scientists regimented and muzzled, with all of us under constant surveillance against the smuggling and planting of time-bombs, and constantly alerted against attack through the air.

Before we commit ourselves to any such intolerable procedure, we should be mad not to explore all possible means for making it unnecessary.

The Only Feasible Alternative Is Effective International Control

This cardinal principle has been recognized in the statement of November 15th, issued jointly by President Truman, and Prime Ministers Attlee and King. Their statement frankly concedes that against atomic weapons there can be no adequate military defense, that no nation can command a monopoly of such weapons, that responsibility for eliminating atomic energy as an instrument of war and for devising safeguards over its use for the advancement of science and other peaceful and humanitarian ends rests upon the civilized nations of the world.

They propose that a commission be set up at once under the United Nations Organization to make recommendations: (a) for extending between all nations the exchange of basic scientific information for peaceful ends, (b) for control of atomic energy to the extent necessary to ensure its use only for peaceful purposes, (c) for the elimination from national armaments of atomic weapons and of all other major weapons adaptable to mass destruction, and (d) for effective safeguards by way of inspection and other means to protect complying states against the hazards of violations and evasions.

Already criticism is leveled at the wording of the statement, at alleged omissions, at the wisdom of choosing the United Nations Organization as the medium through which to seek agreement in view of the weaknesses of the UNO Charter.

None of these issues should be crucially important. What matters is that an invitation has been issued in good faith for the nations of the world to meet and decide upon means for assuring the elimination of weapons, the existence of which no one can afford to tolerate.

The decision cannot be other than international; it will require the best thought of the best brains the world can muster. The smaller nations have an equal stake with the large, and from them may well come the most fruitful suggestions. But Russia now holds the key to the success or failure of our proposal. If she accepts our invitation, no other nation will refuse.

Alternatively, there will be an international armament race paced by atomic weapons. It will mean an end of free science, a severe policing and regimentation of international travel and trade, and innumerable restrictions upon those individual freedoms which we have just fought so desperately to preserve. This is the dismal prospect if we fail to arrive at a genuinely international accord on the control of atomic energy. But even this interval would promise to last only for an uneasy period, until someone started pressing the push-buttons on the panel-boards of extinction.

The only permanent solution lies in finding means to eliminate war itself. That we cannot hope to achieve overnight, but we can, and do hope that the nations will now agree to eliminate atomic weapons and their radioactive by-products as instruments of war.

If they do that, we can move forward more surely to the constructive development of the incalculably valuable resources that science has newly opened to our use. And, we can hope also for a progressive improvement in international understanding.

Unless the nations can reach agreement on this paramount issue of atomic energy, it is difficult to conceive of any vital issue on which they might agree.

President, McGraw-Hill Publishing Co., Inc.

THIS IS THE 42ND OF A SERIES

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High power output, long life, feature these transmitting tube stalwarts!

- TYPE GL-892
  Water-cooled . . . $170
- TYPE GL-892-R
  Forced-air-cooled . $345

HERE is *proved* power, dependability, and long service life for the large AM transmitter owner or the manufacturer using electronic heating. General Electric Types GL-892 and GL-892-R have demonstrated their reliability in broadcasting and industrial sockets operating 24 hours a day, 7 days a week. With broad applications as high-power amplifiers, modulators, and oscillators, Types GL-892 and GL-892-R also are adaptable as to filament supply, their 2-unit filament permitting operation from 2-phase or single-phase a-c, as well as from d-c. For complete data to supplement the basic ratings at the right, see your nearest G-E Office or distributor, or write *Electronics Department, General Electric Company, Schenectady, N. Y.*

Come to GENERAL ELECTRIC with any special tube problems. A staff of experienced G-E tube engineers will work with you closely to meet your application or replacement needs.

CHARACTERISTICS

Three-electrode high-vacuum power tubes for use as amplifiers and modulators in broadcasting and communications equipment—also oscillators in industrial electronic heating. Besides Types GL-892 and GL-892-R shown above, Types GL-891 and GL-891-R also are available at the same prices, and are similar in design characteristics except for the amplification factor, as given below.

Rating	GL-892	GL-892-R	GL-891	GL-891-R
Filament voltage	11 v	11v	11v	11 v
Filament current	60 amp	60 amp	60 amp	60 amp
Max plate voltage	15,000 v	12,500 v	12,000 v	10,000 v
Max plate current	2 amp	2 amp	2 amp	2 amp
Max plate input	30 kw	18 kw	18 kw	15 kw
Max plate dissipation	10 kw	4 kw	6 kw	4 kw
Amplification factor	50	50	8	8

Notes: (1) Filament voltage and current given above, are per unit of 2-unit filament. (2) Maximum frequency for all four tube types is 1.6 megacycles at max plate input; up to 20 megacycles at reduced ratings.

TRANSMITTING, RECEIVING, INDUSTRIAL, SPECIAL PURPOSE TUBES · VACUUM SWITCHES AND CAPACITORS

GENERAL ELECTRIC

161-D12-8850

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MICRO-TEL RELAY

Television's first MICROWAVE link

GENERAL ELECTRIC'S Micro-Tel relay—first 2000-megacycle radio relay in history—heralds a new era in network operation that will bring television and FM to more people at less cost.

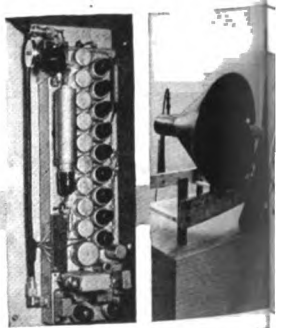
● This simple relay, which eliminates connecting wire lines and costly right-of-ways, consists of a low-power microwave FM transmitter, a microwave FM receiver, *and a highly directional transmitting and receiving antenna system which gives each watt of transmitter power the effectiveness of approximately one million watts.* The system is simple, economical and provides unattended operation.

● Today, General Electric is testing a Micro-Tel link between the studio and transmitter of its great television station WRGB in Schenectady —a distance of 12½ airline miles.

Soon, the world's first television microwave relay — equipped by G. E. and operated by the International Business Machines Corp. — will be added. This relay will extend to New York, Philadelphia, Baltimore, and Washington. Additional links will follow . . . for television programs, full fidelity channels for network broadcasting, facsimile channels, and multiple business machine channels — simultaneously in both directions.

● Further expansion of this network and the establishment of others will bring television, broadcasting, and business machine services to smaller communities.

● Whether your requirements are for Micro-Tel relays, complete television broadcast stations, or Intra-Tel systems, look to General Electric for your equipment. Plan now to visit Schenectady to study G-E broadcast facilities. Wednesdays and Fridays are "open house" days. Write for the folder "How to Get To Schenectady," or ask your G-E broadcast equipment representative to help you plan your visit. *Electronics Dept., General Electric Company, Schenectady 5, N. Y.*



Receiving antenna and receiver for General E... experimental Micro-Tel link in Schenectady... extreme simplicity of installation. The ... antenna is only 2 feet in diameter.

Authentic Guide to Television Programming

Write for the new book "Television Show Business," by Judy Dupuy. Published by General Electric. $2.50 per copy. Address: Electronics Department, General Electric Company, Schenectady 5, N. Y.

For earliest possible delivery of your broadcast equipment, place your order *now*.

STUDIO ... EQUIPMENT • TRANSMITTERS

GENERAL ELECTRIC

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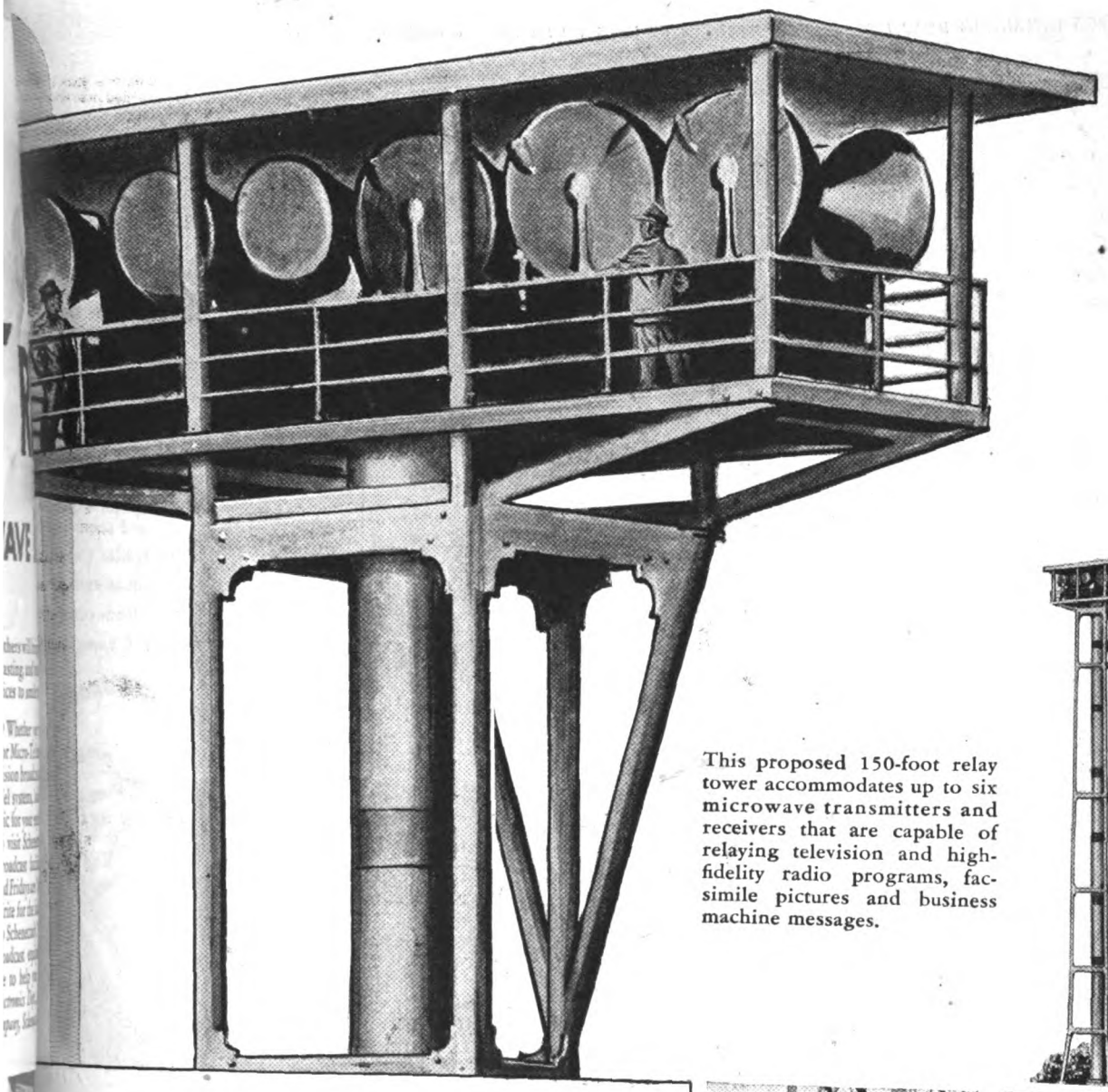
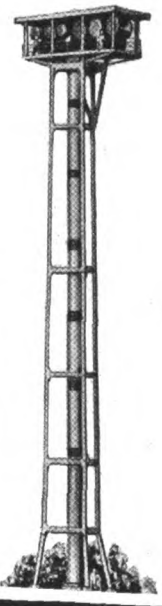
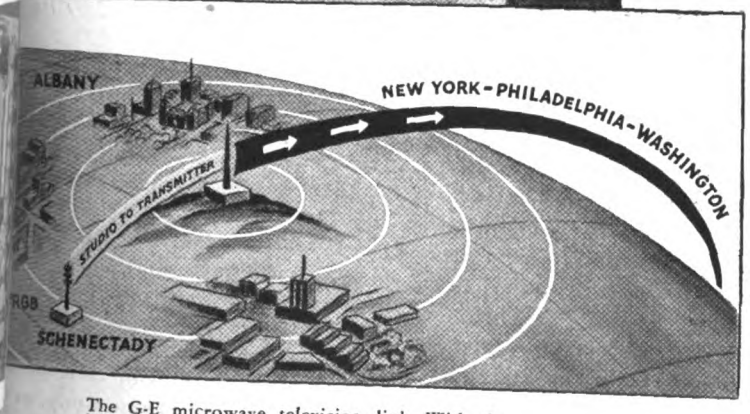
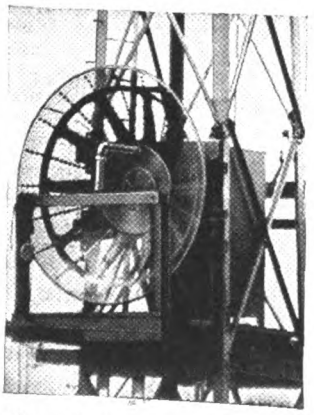


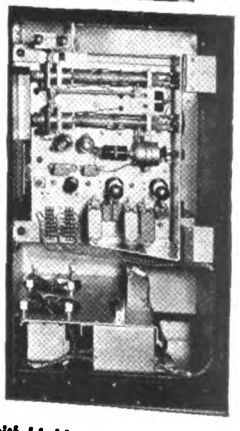
This proposed 150-foot relay tower accommodates up to six microwave transmitters and receivers that are capable of relaying television and high-fidelity radio programs, facsimile pictures and business machine messages.





The G-E microwave television link. With the Micro-Tel relay, G.E. contributes another major development in television and broadcasting.





Micro-Tel link transmitter and antenna with highly directional reflector atop mast at WRGB. This system gives each transmitted watt of output the effectiveness of approximately 1,000 watts.

se tubes make television microwave relaying possible. For maximum station dependability and performance, use G-E electronic tubes.

TENNAS • ELECTRONIC TUBES • HOME RECEIVERS

M • TELEVISION • FM

See G.E. for all three!

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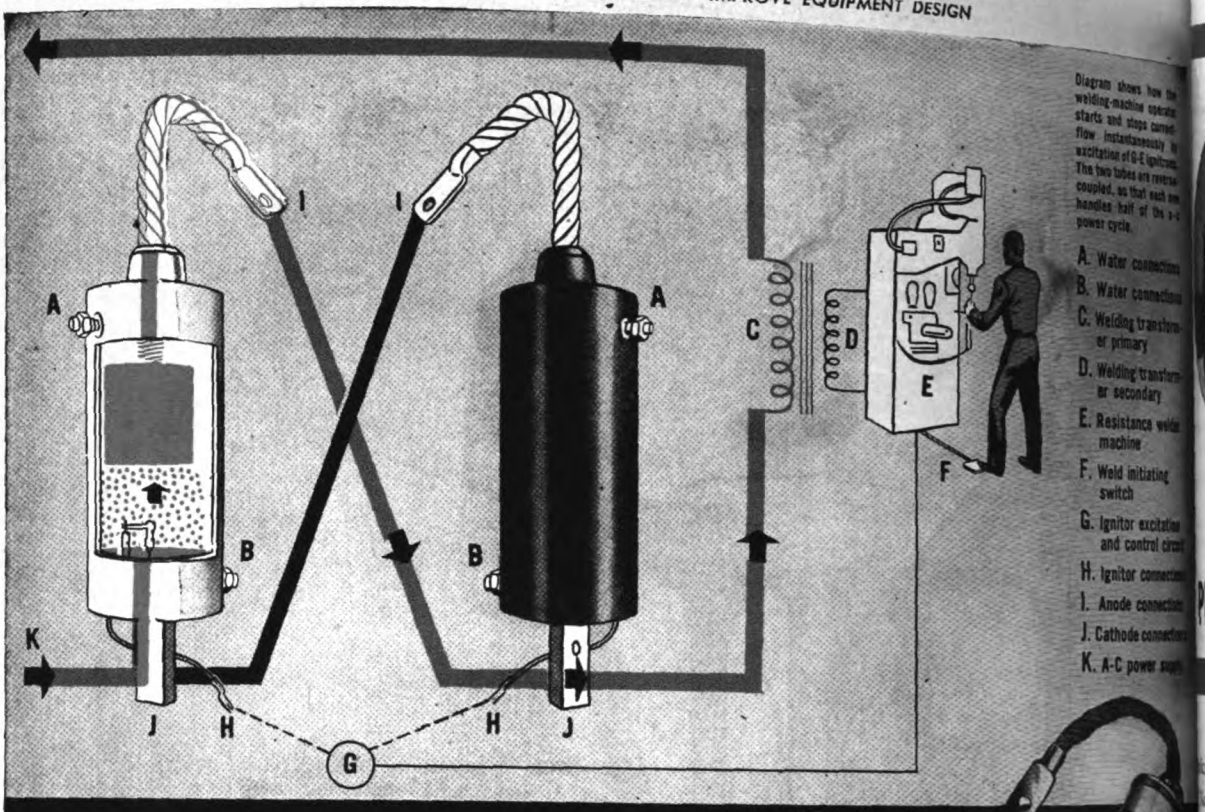
ONE OF A SERIES EXPLAINING HOW ELECTRONIC TUBES CAN BE USED TO IMPROVE EQUIPMENT DESIGN



IGNITRONS "trigger" the heavy currents for resistance welding

AN important use of G-E ignitron tubes is shown above—controlling the primary current of resistance welders. The same benefits of split-second, positive "valve" action, with no mechanical linkage and no arcing between movable contacts, are provided by G-E ignitrons for other control circuits—furnace, motor, etc.—involving heavy electrical currents.

● Current control is but one of this tube's functions in industry. Another is current conversion—a-c to d-c. Here ignitrons offer the advantages of silent operation, no rotating parts, no need for lubrication, no mechanical upkeep.

●Steel-jacket construction and mercury-pool type cathode, among other features, make the G-E ignitron sturdy, dependable, and long-lived. Learn more about this versatile electronic tube from G. E.'s new Booklet ETI-21, "Ignitron Tubes and How They Are Used." Its 24 profusely illustrated pages, complete with selected circuits, tell the full story of ignitrons and how they serve industrially. Telephone your nearest G-E office or distributor, or write *Electronics Department, General Electric Company, Schenectady 5, New York.*

IGNITRON FG-235-A . . . $75

This tube is one of the most widely used G-E ignitrons. It is a steel-jacketed, water-cooled, gas-filled triode with mercury-pool cathode, used for welder and other heavy current controls, and as a low-power current converter. For welder control service, ratings are: max kva demand 1,200, with corresponding avg anode current 75.6 amp—max avg anode current 140 amp, with corresponding kva demand 400. (These ratings are for voltages of 600 v rms and below.) Ignitor requirements are 200 v and 30 amp. . . . Ratings for current conversion will be supplied on request, in which case please include a brief description of the application or circuit.

G. E. HAS MADE MORE BASIC ELECTRONIC TUBE DEVELOPMENTS THAN ANY OTHER MANUFACTURER

GENERAL ELECTRIC

TRANSMITTING, RECEIVING, INDUSTRIAL, SPECIAL PURPOSE TUBES ★ VACUUM SWITCHES AND CAPACITORS

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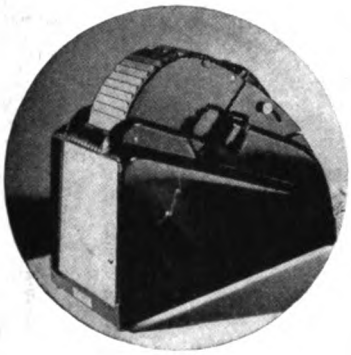

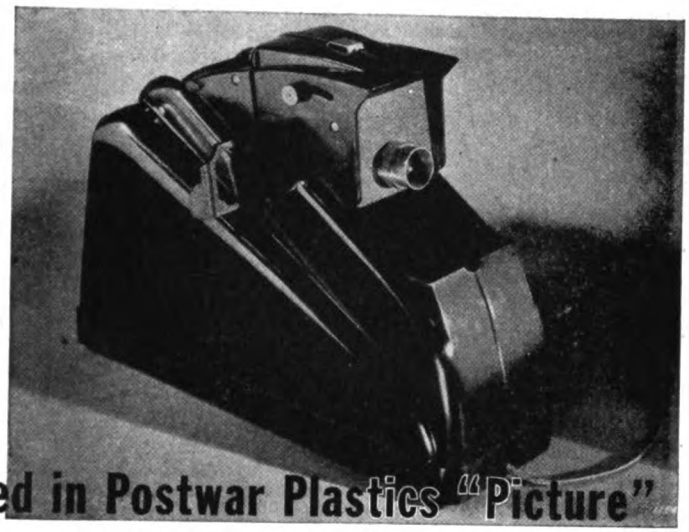

Phenolics featured in Postwar Plastics "Picture"

The phenolics are the most versatile of all plastics. Naturally, this makes their use practically universal throughout industry. In the electrical manufacturing field, for example, you will find phenolic molding compounds being used for literally thousands upon thousands of vital parts. The Novex Combination Projector Viewer shown above serves as an excellent illustration of this point. Its sturdy heat-resistant plastic housing was molded from a Durez phenolic compound.

This Novex Combination Projector Viewer effectively demonstrates the practical, sales-stimulating use to which Durez phenolic molding compounds can be put. Its durable, eye-appealing 14"-long body is molded in one piece. The complete unit embodies several molded Durez parts. With molded-in inserts, these, naturally, help to make assembly a simple process and keep production costs at a minimum.

Heat-Resistant Housing

By molding the housing for this Combination Projector Viewer of Durez, the manufacturers gain the heat-resisting and heat-insulating characteristics so necessary for the efficient operation of a machine of this type. Furthermore, a rugged yet lightweight construction results.

Properties of the Phenolics

Just as the Novex Corporation found a Durez phenolic plastic that fitted their job, so have many other manufacturers. Such desirable properties as heat and moisture resistance and dielectric strength make Durez compounds of unusual value to electrical manufacturers. Additional inherent characteristics such as highest dimensional stability at temperature extremes, excellent moldability, and impact strength make them extremely useful to the automotive industry. Closure manufacturers find the eye-appealing, non-bleeding finish of molded Durez to be the answer to their materials problems. Time and again the versatility of the more than 300 Durez phenolic molding compounds has provided the solution to the materials problems of the imaginative design engineer.

Competent Assistance Available

The Durez laboratory technician is an experienced man. Years of successful development work and the continuing leadership of Durez phenolic plastics attest this. Your custom molder is also an experienced man. Many new molding methods and processes make his service even more valuable than before. Put these two men together and you'll stand an excellent chance of coming up with the answer to any practical plastic materials problem which you may have. The services of the Durez staff are available at all times to you and your custom molder. Durez Plastics & Chemicals, Inc., 3212 Walck Road, North Tonawanda, N. Y. *Export Agents: Omni Products Corporation, 40 East 34th Street, New York 16, N. Y.*

PLASTICS THAT FIT THE JOB

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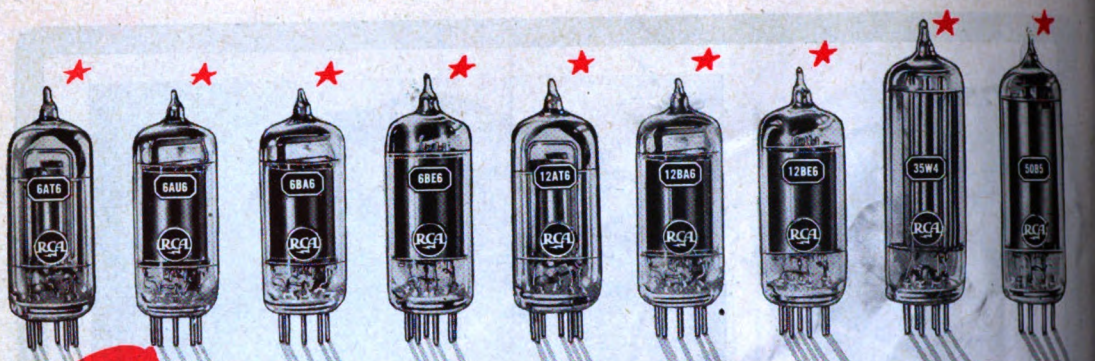

9 NEW RCA MINIATURES!

INCLUDES NEW COMPACT TYPES FOR AM, FM, AND TELEVISION RECEIVERS

Here it is—that latest addition to the peacetime line of miniatures . . . 5 new miniature types that provide performance equivalents for the popular prewar kit 12SA7, 12SQ7, 12SK7 (or 12SG7), 35Z5GT/G, and 50L6GT—and 4 other tubes introduced as performance equivalents to the 6SA7, 6SG7, 6SQ7, and 6SH7.

These 9 new RCA miniatures bring to 35 the total number of tubes in the RCA miniature line—*and all but 2 were developed by RCA engineers.*

Such RCA pioneering means two important things to you:

1. That RCA knows your needs—keeps an eye on the industry—is ever striving to give you the tubes you want when you want them.
2. As the originator of miniatures and as the largest producer of them ever since their introduction, RCA can assure you of superior tube quality and uniformity at prices that are right.

For data on these 9 new tubes, send coupon.

If you are designing radio equipment and need tube-application assistance, don't forget that the RCA application-engineering staff is always at your service for consultation. A telephone call to our nearest office, or a letter stating your problem, will do the trick. Address: Radio Corporation of America, Tube Division, Commercial Engineering Department, Section 62-41E, Harrison, N. J.

In Metals, Miniatures, or Glass Types . . .

THE FOUNTAINHEAD OF MODERN TUBE DEVELOPMENT IS RCA

AND HERE THEY ARE!

	Miniatures New Types	DESCRIPTION	Performance Equivalent
★	6AT6	Duplex-Diode High-Mu Triode	6SQ7
★	6AU6	RF Amplifier Pentode with Sharp Cutoff	6SK7
★	6BA6	RF Amplifier Pentode with Remote Cutoff	6SG7
★	6BE6	Pentagrid Converter	6SA7
★	12AT6	Duplex-Diode High-Mu Triode	12SQ7
★	12BA6	RF Amplifier Pentode with Remote Cutoff	12SG7 (or 12SK7)
★	12BE6	Pentagrid Converter	12SA7
★	35W4	Half-wave High-Vacuum Rectifier	35Z5GT/G
★	50B5	Beam-Power Amplifier	50L6GT

MAIL THIS TODAY FOR FREE DATA SHEETS

RCA, Commercial Engineering Department,
Section 62-41E, Harrison, N. J.

I'd like all the data available on the 9 new RCA miniatures announced in your December advertisement. Please rush me a complete set of data sheets, including ratings, curves, drawings, etc.

Name.....

Position.....

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RCA

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RADIO CORPORATION OF AMERICA

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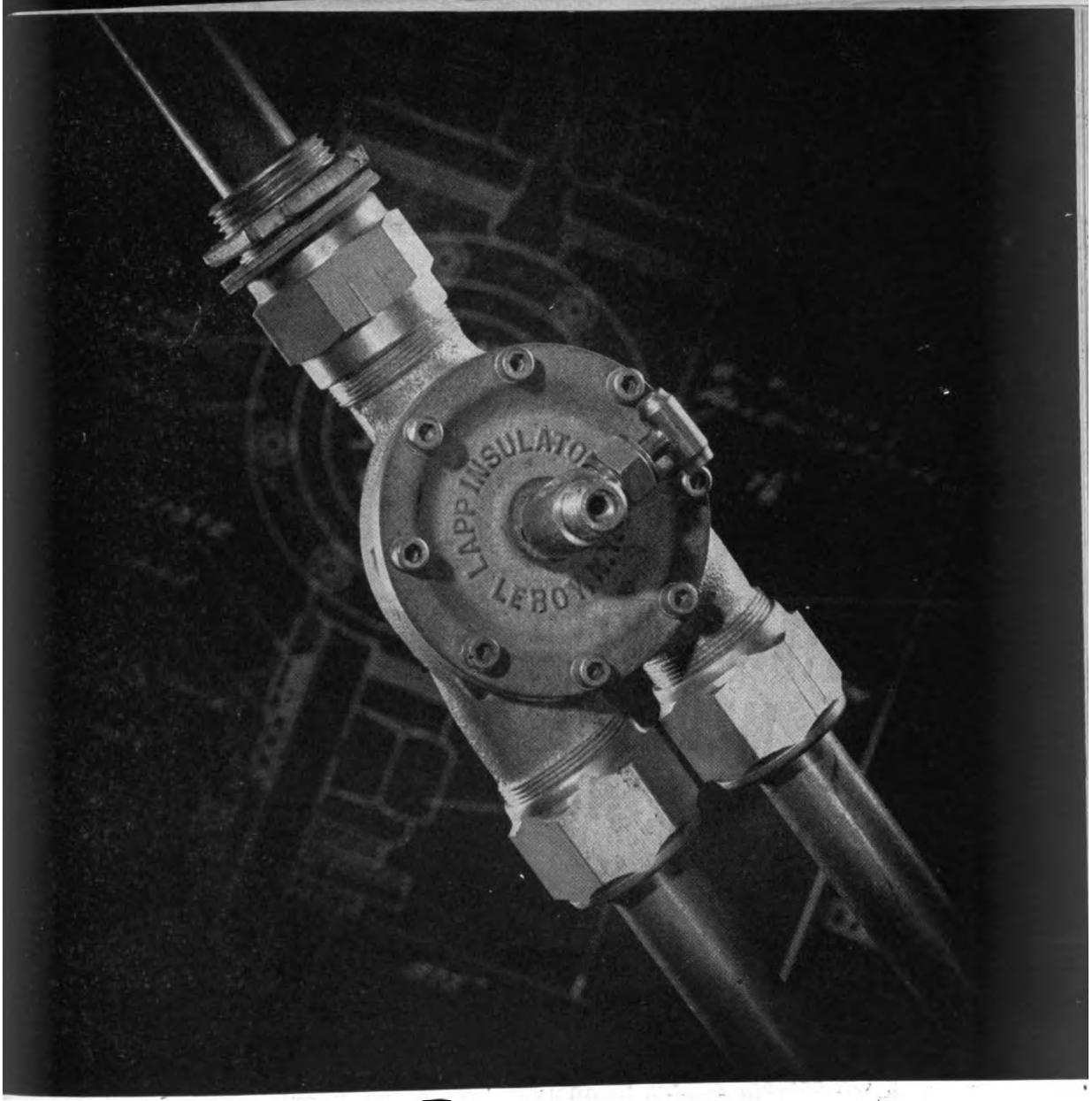

Electronic Parts: ENGINEERING AND PRODUCTION

The gadget above is a junction box for a co-axial gas-filled transmission line. It is one of a series of coupling units, end seals and other fittings for high-frequency transmission—designed and built by Lapp.

To this type of construction, Lapp brings several innovations and improvements. For example, such a line from Lapp parts is genuinely leak-proof. Every gasket is under spring loading, so there's no leakage created by vibration or thermal change.

Whether or not you're interested in gas-filled transmission lines, you ought to know about Lapp. Here is an organization of engineers and manufacturers with broad basic knowledge of ceramics and their application. With experience in hundreds upon hundreds of special-purpose electronic parts, we have been able countless times to improve performance, or reduce costs, or cut production time through the application of our specialized skills to design and manufacture of parts involving porcelain or steatite and associated metal parts.

For quick and efficient assistance on a war production subcontract—or for the competitive advantage Lapp-designed and Lapp-built parts will give to you in the postwar battle—an inquiry to Lapp now may pay you dividends. *Lapp Insulator Co., Inc., LeRoy, N. Y.*

Lapp

ARMY E NAVY

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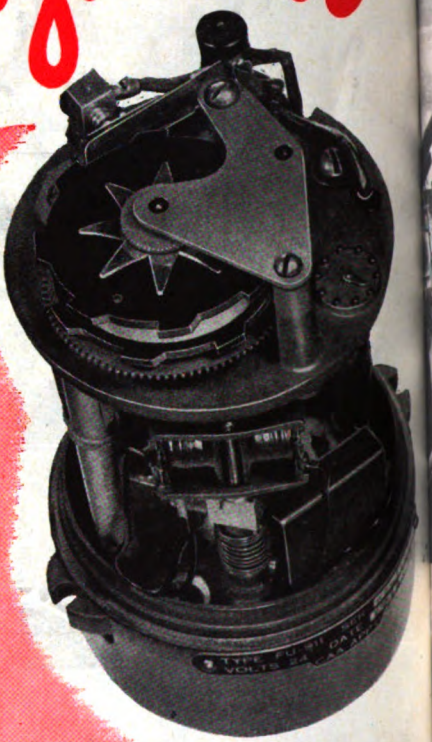
SPLITS SECONDS "just so"

THE W&T CONSTANT SPEED MOTOR MECHANISM meets precision standards



Type FA-121 for 12 volt operation
Type FA-122 for 24 volt operation

FOR coding, keying, monitoring, programming, or other timing applications this instrument, operating at a constant speed, regardless of voltage variations as great as ±20%, permits accurate timing to hundredths of a second.

With a current input of only 0.003 milliamperes, the motor delivers 1800 gram inches per minute, a feature of especial importance in battery powered systems.

Interchangeable cams permit the use of any desired timing characteristic for two or more separate circuits.

Write for Technical Publication 234

WALLACE & TIERNAN
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BELLEVILLE 9 • NEW JERSEY

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CERAMICS

SO RUGGED THEY COULD WITHSTAND THE SHOCK OF BEING FIRED FROM A GUN WITH A FORCE OF 20,000g in the 'RADIO PROXIMITY FUSE'

War's Number 2 Scientific Development

AlSiMag Ceramic Insulators were extensively used in condensers for the 'Radio Proximity Fuse' described by high Navy officials as second only to the atomic bomb among the greatest scientific developments of the war.

Development of the fuse required production of electronic parts so rugged they could withstand the shock of being fired from a gun with a force 20,000 times that of gravity. The components had to be so small that a complete unit could be installed in the nose of a projectile.

The fuse, developed at a cost of $800,000,000 is an extremely rugged, five tube radio sending and receiving station which fits into the nose of a projectile. Reflected impulses explode the projectile when it passes within 70 feet of enemy planes.

The 'Radio Proximity Fuse' was the effective answer to Japanese suicide plane attacks, as well as buzz bomb attacks on London.

American Lava Corporation is justly proud of the fact that it was able to provide the Ceramic Insulators capable of withstanding the tremendous shock of being fired from a gun in the 'Radio Proximity Fuse.'

Whatever you are planning in the field of electronics, we believe our specialized knowledge, research and production facilities will prove helpful. Let's work together.

ALCO has been awarded for the fifth time the Army-Navy "E" Award for continued excellence in quantity and quality of essential war production.

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENNESSEE

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43RD YEAR OF CERAMIC LEADERSHIP

THE COMBINED RESULT IS EXCELLENCE . . .

1 MICA SPLITTING

2 MICA GAUGING

3 MICA PUNCHING

5 CAPACITOR ASSEMBLY

6 HAND STACKING

7 CHECKING CAPACITANCE

9 CAPACITOR MOULDING

10 CLEANING & INSPECTING

11 FINAL TESTING

SANGAMO ELECTRIC

ESTABLISHED 1898 • • • MICA CAPACITORS • • •

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IN Sangamo

4 MICA INSPECTION

CARTRIDGE IMPREGNATION

RESEARCH & ENGINEERING

MICA CAPACITORS

•

In our series of advertisements just completed, we have attempted to show "How Excellence is built into Sangamo Mica Capacitors" through featuring one department or process each month.

This review, depicting the various steps in the manufacture of a mica capacitor is a reminder of how important the SANGAMO MICA CAPACITOR production set-up is to you in the matter of quality control from the first operation – MICA SPLITTING—all the way through to the final operation–FINAL TESTING.

WRITE FOR *Catalog*

As a user of MICA CAPACITORS, you will want to have the story of SANGAMO EXCELLENCE for reference. Therefore, we have bound the entire series of advertisements featuring the departments shown here, into a booklet. Simply write and ask for your copy of the booklet "HOW EXCELLENCE is built into SANGAMO MICA CAPACITORS."

•

COMPANY SPRINGFIELD ILLINOIS

• • WATT HOUR METERS • • • TIME SWITCHES • • •

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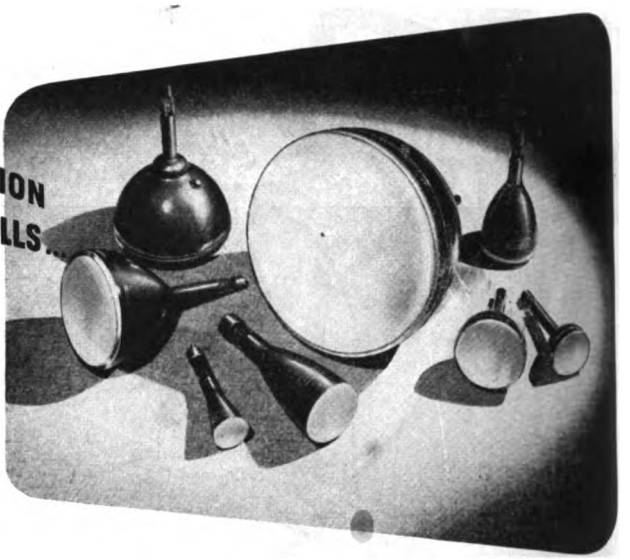
DIRECT-VIEWING TELEVISION RECEPTION AT ITS BEST, SPELLS...



DuMONT TELETRONS*

WHY DIRECT-VIEWING TELEVISION RECEPTION?

Because . . .

- Excellent pictorial resolution due to minimum spot size.
- Higher brilliance and better contrast range for vivid pictures.
- Wide-angle viewing, accommodating the largest audience for given screen size.
- Lower accelerating voltage, which means less costly receiver power supply.
- Simplicity of the focusing system, since it is entirely electronic.
- Longer tube life and therefore lower operating cost.
- Previous objections to curvature of face have been overcome by design of essentially flat-faced bulbs.
- DuMont offers the larger image tubes for adequate screen sizes and the greatest receiver value.

*REG. TRADE-MARK

It's *all in the tube* when dealing with direct-viewing television reception. The image is viewed directly as scanned. No mirrors or lenses; no dust or dirt to dim the image; no realignments ever required. The *complete* device for image reproduction is *permanently* set and sealed *at the plant.*

DuMont has led in the development and production of large-image cathode-ray tubes for television (Teletrons) in all sizes and types.

DuMont Teletrons make direct-viewing practical, logical, and truly economical.

• • •

Interested? Our engineers are ready to collaborate in fitting the right Teletron to your particular problem. Technical data on request.

Remember, DuMONT also makes other types of cathode-ray tubes, oscillographs, television receivers and television transmitting equipment.

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DUMONT *Precision Electronics & Television*

ALLEN B. DuMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.

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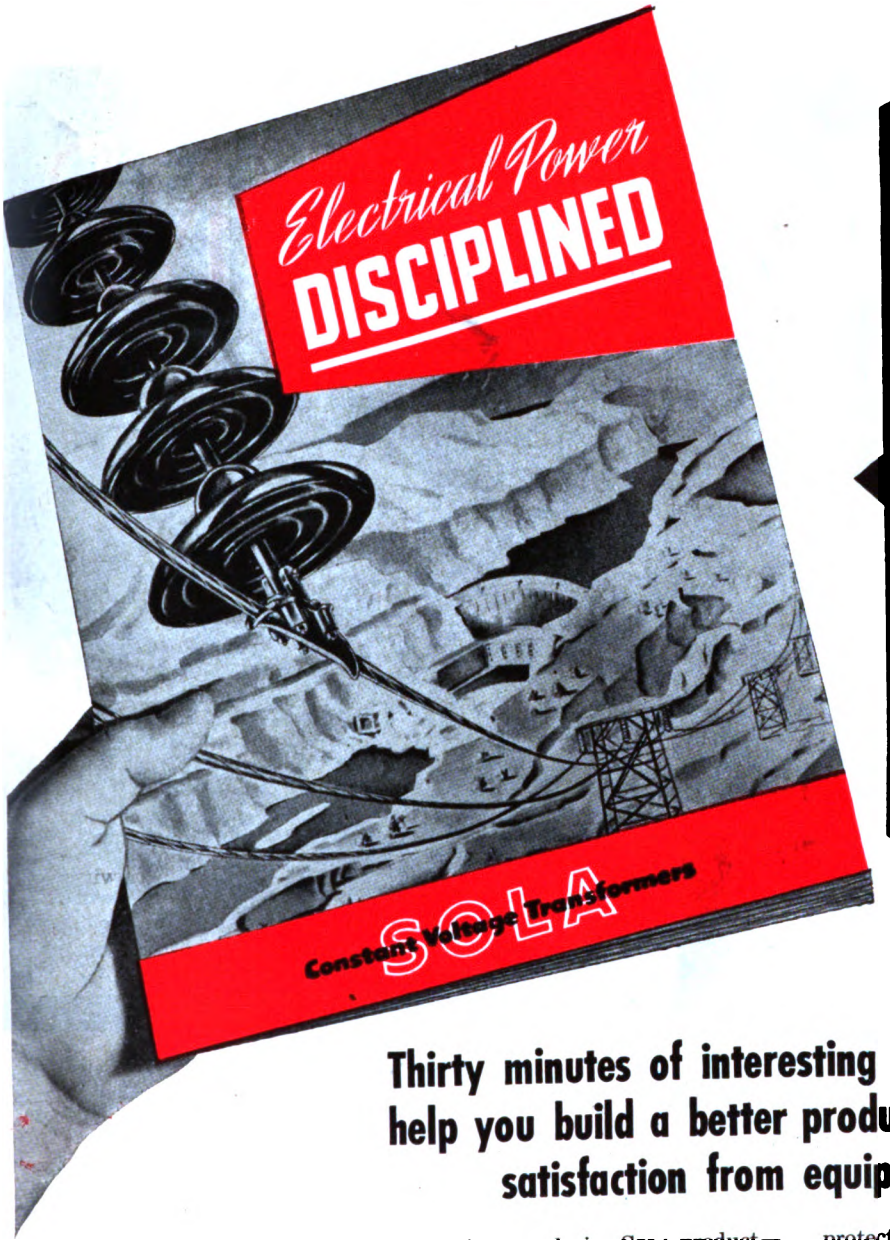

for:

designers

•

manufacturers

•

maintenance engineers

•

salesmen

•

users of electronic and electrically operated equipment

Thirty minutes of interesting reading that will help you build a better product or get greater satisfaction from equipment now in use

What is a Constant Voltage Transformer?—why is it necessary?—how does it operate?—where can it be used?—what new developments have resulted from its world-wide, war-time use?—

. . . these and many other important questions are fully answered in this new SOLA handbook.

The Constant Voltage Transformer is an exclusive SOLA product—the ONLY voltage regulating TRANSFORMER. In principle, design and construction it is different and should not be confused with ordinary types of voltage regulating networks.

It employs no tubes and has no moving parts. It is fully automatic in operation, it is not dependent on manual control or supervision and protects both itself and the equipment it serves against voltage surges or short circuit. It instantly corrects voltage fluctuations as great as 30% to within ±1% of rated value.

Your product will serve more people—*better*—with built-in Constant Voltage. There are SOLA units specially designed for that purpose—fully described in this new handbook.

Write for your copy

You will find in this handbook a final answer to the problem that confronts every manufacturer or user of electrically operated equipment.

Ask for Bulletin DCV-102

Constant Voltage Transformers SOLA

Transformers for: Constant Voltage • Cold Cathode Lighting • Mercury Lamps • Series Lighting • Fluorescent Lighting • X-Ray Equipment • Luminous Tube Signs Oil Burner Ignition • Radio • Power • Controls • Signal Systems • etc. **SOLA ELECTRIC COMPANY, 2525 Clybourn Avenue, Chicago 14, Illinois**

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In flight tests at Wright Aeronautical, a Western Electric sound analyzer is used to measure sound characteristics of the plane and locate major sound disturbances.

Why Western Electric equipment leads the way!

1. Western Electric products are designed by Bell Telephone Laboratories — world's largest organization devoted exclusively to research and development in all phases of electrical communication.

2. Since 1869, Western Electric has been the leading maker of communications apparatus. During the war this company was the nation's largest producer of electronic and communications equipment.

3. The outstanding quality of Western Electric equipment has been proved daily on land, at sea, in the air, under every extreme of climate. No other company supplied so much equipment of so many different kinds for military communications.

Western Electric

Today's world is a world of sound. How different it would be without the telephone, radio, public address systems, aids for the hard of hearing, talking pictures!

For many years, Bell Telephone Laboratories and Western Electric — working closely as research and manufacturing teammates — have led the way in building this world of sound.

In the course of their sound-transmission work, these teammates

Western Electric has specialized

AM • BROADCASTING • FM | TELEVISION | AVIATION RADIO | MARINE RADIO

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A powerful Western Electric public address system spreads sound evenly throughout New York's huge Madison Square Garden which seats more than 18,000 people.

equipment leads the way!

have also developed scientifically accurate instruments for *measuring* and *analyzing* sound and vibration. These instruments have many important uses today—will have still more tomorrow.

Through their lifetime of pioneering in this field, Bell Labs and Western Electric have gained a unique knowledge of sound and how to handle it. Count on them for the finest equipment for measuring sound or spreading it around!

Buy all the Victory Bonds you can . . . and keep all you buy!

knowledge in all of these fields

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How KARP cuts costs on sheet metal fabrication

Every job we do is a special-built job, individualized to exact specifications. Yet our superior machine installations and vast stocks of dies and jigs permit us to fabricate your order economically and with precision—frequently saving you the cost of special dies.

Since 1925, our specialty has been the fabrication of cabinets, housings, chassis and enclosures for electronic, electrical and mechanical apparatus. Prior to and during the war, we continued and intensified **this specialty, and shall now continue it in peace. Therefore, we are not reconverting to any other line We are not a "war baby"—but our wartime experience has added to our facilities and abilities.**

Tell us your sheet metal fabrication needs. We can serve you with satisfaction and speed. More often than not, we can save you money, too.

ARMY E NAVY

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ANY GAUGE • ANY FINISH

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Custom Craftsmen in Sheet Metal

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READY TO SERVE YOU AGAIN!

Thordarson has returned from the war and is ready *now* to serve its many customers. *Thordarson* regrets there has been an interruption in service performance to regular customers and that orders could not be filled during the war. Here's the reason.

The superior quality of *Thordarson* transformers and other electronic devices was recognized immediately by Uncle Sam at the outbreak of the war and *Thordarson* production (100%) was required to fill all-important government orders.

Now the same high quality that was so acceptable in the recent emergency is available to you. *Thordarson* transformers—always the gauge of superior quality and unexcelled performance—are now even better because of many new additions and developments made during the war. *Thordarson* research-engineering plus *Thordarson* quality team together in the production of better equipment and devices for the electronics industry.

New distribution policies and sales promotion plans make *Thordarson* products and complete informative data on their application and use available to all customers—everywhere!

ALWAYS THINK OF *THORDARSON* FOR TOP-NOTCH TRANSFORMERS!

500 WEST HURON ST., CHICAGO, ILL.

ORIGINATORS OF TRU-FIDELITY AMPLIFIERS

THORDARSON

ELECTRIC MANUFACTURING DIVISION

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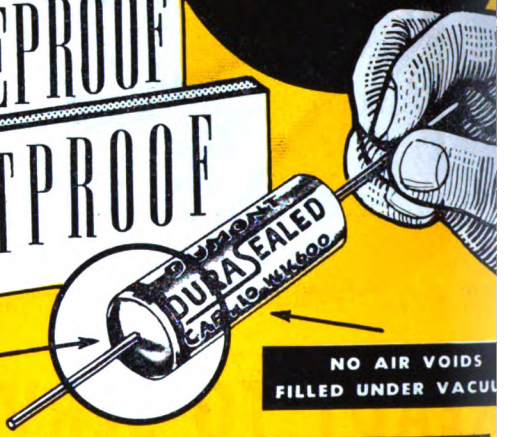
TYPE P6



DUMONT RESINOID SEALED • WILL NOT MELT AT 300° F

NO AIR VOIDS FILLED UNDER VACUU

CAT. NO.	CAPACITY MFD	200 V.D.C. SIZES DXL	400 V.D.C. SIZES DXL	600 V.D.C. SIZES DXL	1000 V.D.C. SIZES DXL
P6-1	.001	3/8 X 1"	3/8 X 1"	3/8 X 1"	3/8 X 1 1/4"
P6-2	.002	3/8 X 1"	3/8 X 1"	3/8 X 1"	3/8 X 1 1/4"
P6-3	.003	3/8 X 1"	3/8 X 1"	3/8 X 1"	3/8 X 1 1/4"
P6-4	.004	3/8 X 1"	3/8 X 1"	3/8 X 1"	3/8 X 1 1/4"
P6-5	.005	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/4"
P6-6	.006	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/4"
P6-7	.008	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/4"
P6-8	.01	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/4"
P6-9	.02	3/8 X 1"	3/8 X 1"	7/16 X 1"	3/8 X 1 1/2"
P6-10	.03	3/8 X 1"	3/8 X 1 3/8"	1/2 X 1 1/2"	3/8 X 1 1/2"
P6-11	.05	7/16 X 1 3/8"	1/2 X 1 3/8"	1/2 X 1 1/2"	3/8 X 2"
P6-12	.1	7/16 X 1 3/8"	5/8 X 1 3/8"	5/8 X 2"	3/4 X 2"
P6-13	.25	5/8 X 1 3/8"	3/4 X 1 3/8"	3/4 X 2 1/2"	7/8 X 2 1/2"
P6-14	.5	3/4 X 1 3/8"	7/8 X 1 3/8"	3/4 X 2 1/2"	1 X 2 1/2"

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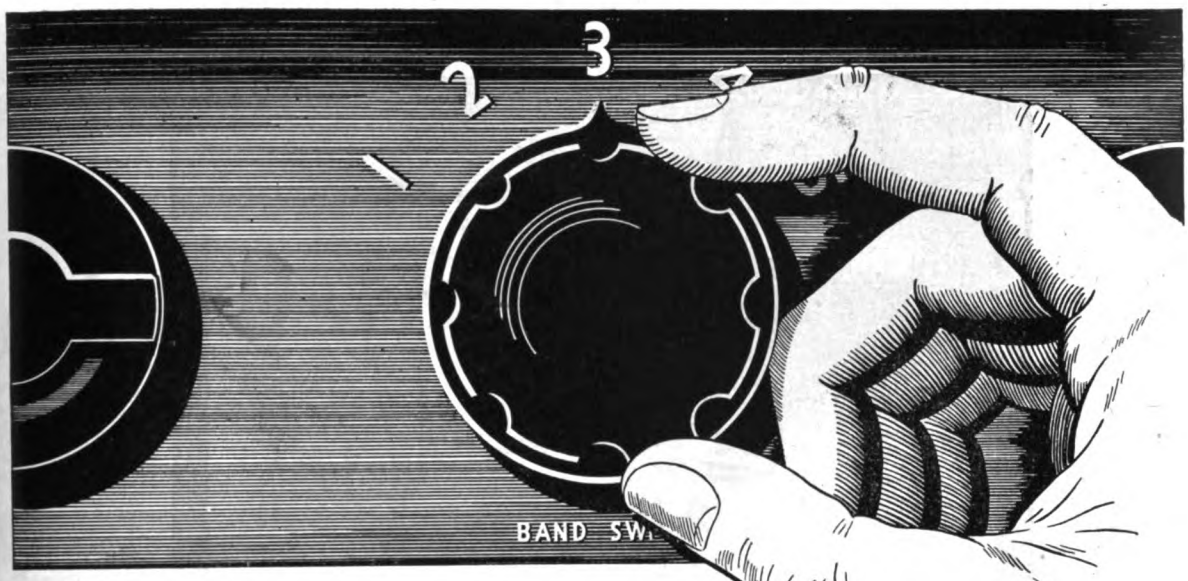

For easier bandswitching use the 257B Gammatron!

The HK-257B beam pentode, originated by Heintz and Kaufman engineers, facilitates the design, construction, and operation of multi-band transmitters since it requires very little driving power and no neutralization.

The wiring diagram below shows a transmitter capable of operating on all amateur bands from 10 to 160 meters. A single 6V6 metal tube in the oscillator circuit drives the r.f. amplifier to its full output. The precise internal shielding of the HK-257B makes neutralization unnecessary.

Write today for complete data on the 257B Gammatron, a versatile tube capable of very high frequency operation.

MAX. PLATE DISSIPATION 75 WATTS

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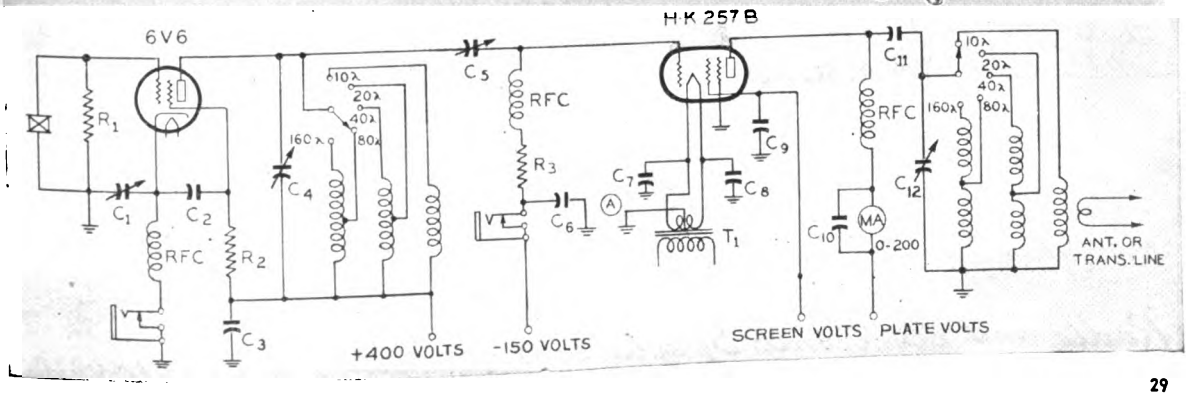

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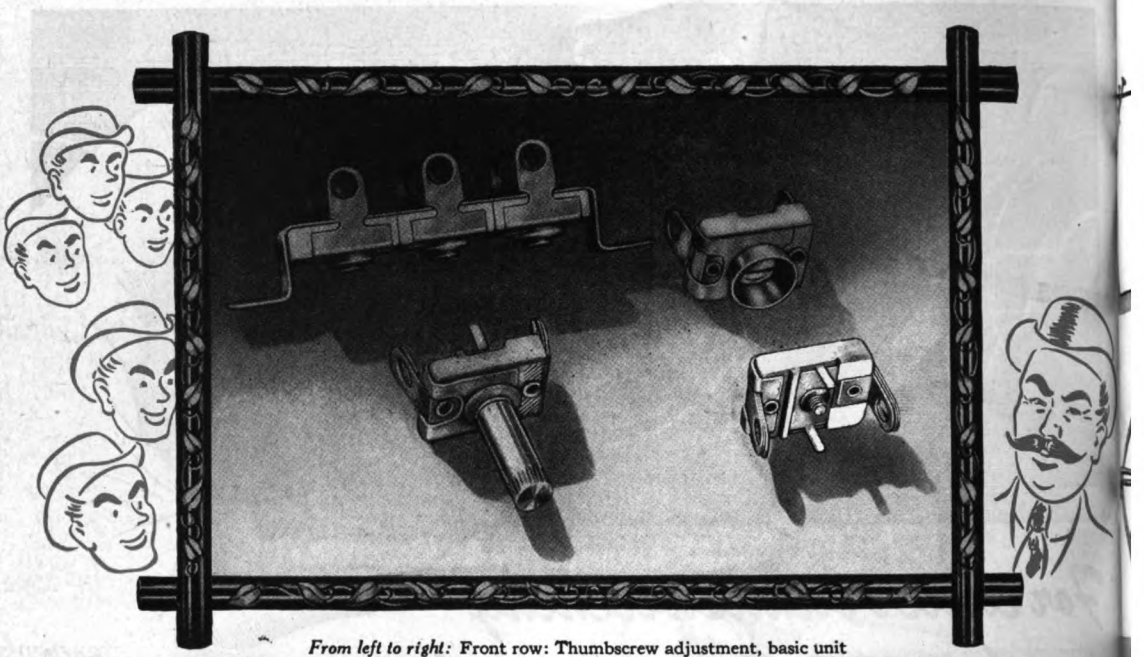

From left to right: Front row: Thumbscrew adjustment, basic unit
Back Row: Multiplicity of brackets, guide cup

The Sickles' ILC Condenser Family

Just like their Dad . . . only more so

In the front row is the "Poppa" of the ILC Sickles' Condenser family. This is the basic unit from which all other ILC's are adapted.

This basic unit is available in six different ranges. It is possible to add silvered mica for increased stability (at some sacrifice of range).

Note a few of the ILC offsprings in the picture above. See their close resemblance to their "Dad." Yet they all have special features. The one in front at left has a thumbscrew adjustment, the one behind it has brackets for as many ILC's in a unit as desired, and the other one has a screw guide cup.

Many different special features are found on other members of the ILC Condenser Family. Write for more complete details.

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Radio and Electronic Specialties for Today and Tomorrow

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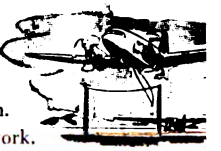
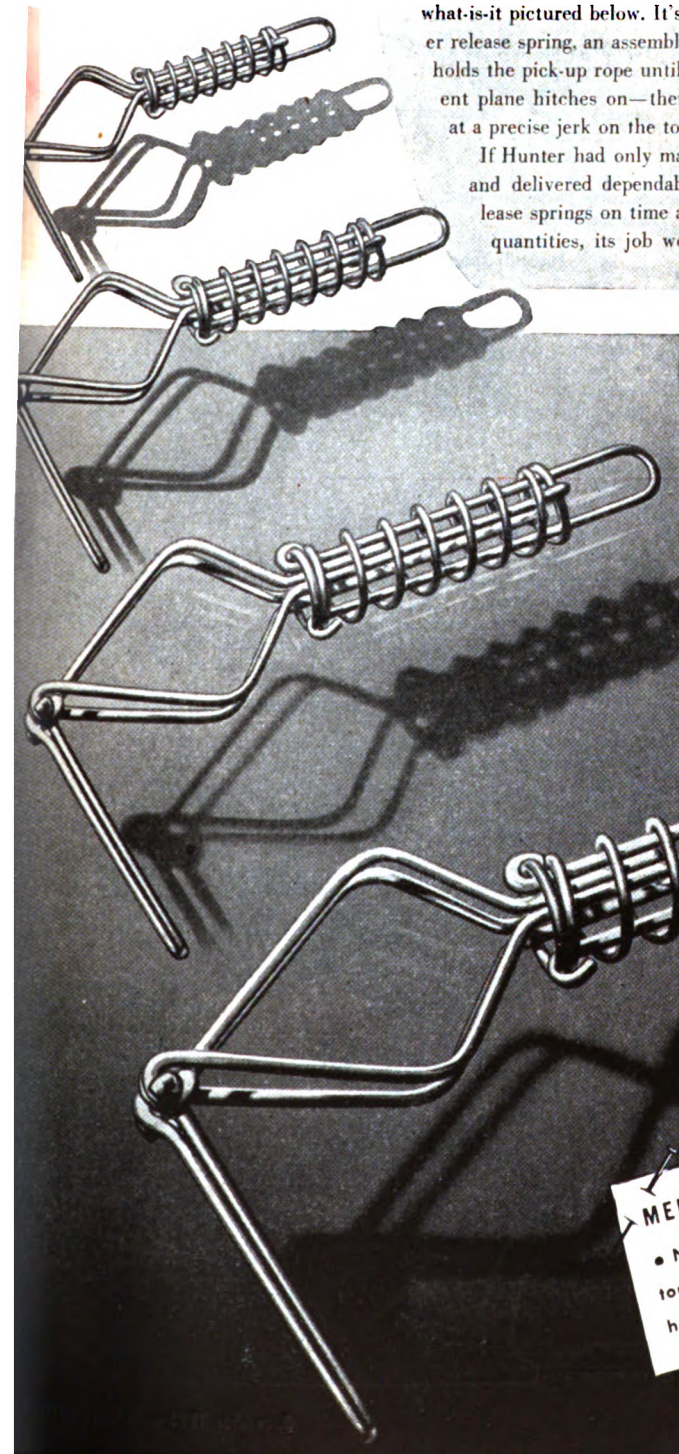
In Springs it's the X-Dimension that gives a Glider and You a Lift



Ever hear of the X-Dimension of a Spring? Probably not. But, sure as you're born it's there, in every spring. Take, for instance, the intriguing what-is-it pictured below. It's a glider release spring, an assembly which holds the pick-up rope until the parent plane hitches on—then let's go at a precise jerk on the towline.

If Hunter had only manufactured and delivered dependable glider release springs on time and in needed quantities, its job would have been satisfactory. But Hunter invented the device for All American Aviation, Inc., and assigned the patents to them. That's the X-Dimension at work.

It's also at work in such pioneering efforts in spring manufacture as control gaging and statistical methods in quality control. It's your guarantee of good springs, your insurance against failures and customer complaints. It's *more* than you bargained for—in springs.



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MEMO TO PURCHASING MEN—

• Next time your engineers hand you a tough spring procurement job, let Hunter help you get your money's worth.

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Announcing RCA-6C24

1100 WATTS OUTPUT AT 160 MEGACYCLES!

PRICE $45.00

TECHNICAL DATA

Filament Voltage (A.C.), volts	11.0
Filament Current, amperes	12.1
Amplification Factor	30
Direct Interelectrode Capacitances, micromicrofarads	
grid-to-plate	4.4
grid-to-filament	4.6
plate-to-filament	3.2
Overall length (less lead wires), inches	6¼"
Max. diameter, inches	1⅞"

Typical Operation at Maximum Plate Volts

	Class B Audio Amplifier or Modulator*	*Class B Telephone R-F Amplifier*	*Plate-Modulated Class C Telephone*	*Class C Telegraph*
Plate Volts	3000	3000	2500	3000
Plate Milliamperes	800#	200	400	500
Driving Power (Approx.) Watts	30#	16	75	75
Power Output (Approx.) Watts	1600#	200	800	1100

*Two tubes #At max. signal

Here's a tube that fills that important need for medium power in the new FM and television bands—a compact and efficient tube for commercial, emergency, government, and industrial service, in the frequency range above that of the popular RCA-833A.

The 6C24 is a triode having low interelectrode capacitances and low lead inductance for high-frequency applications. Forced-air cooling of the sturdy copper radiators results in a simple and convenient system.

The 6C24 is designed for either fixed or portable operation. Takes full input up to 160 megacycles.

Industrial Applications

The 6C24 is rated at both 400 and 600 watts plate dissipation. This higher rating requires increased air flow, but is of particular interest to designers of electronic heating equipment in which it is desired to hold tube and circuit conditions to moderately low efficiencies for conservative operation of the 6C24.

Application Assistance

If you have an application for the 6C24, or for other RCA tubes, and would like the assistance of our application engineers, please write, stating your problem. For technical bulletin on the 6C24, send the coupon for complete technical data, curves, drawings, and application hints. Address: Radio Corporation of America, Tube Division, Commercial Engineering Department, Section 62-102E, Harrison, New Jersey.

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The Fountainhead of Modern Tube Development Is RCA

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RCA, COMMERCIAL ENGINEERING DEPARTMENT
Section 62-102E, Harrison, N. J.

Please send me free bulletin on the RCA-6C24 triode giving complete technical data, drawings, curves, and application hints.

Name.....

Position.....

Company.....

Address.....

City.....Zone.....State.....

RADIO CORPORATION OF AMERICA

TUBE DIVISION · HARRISON, N. J.

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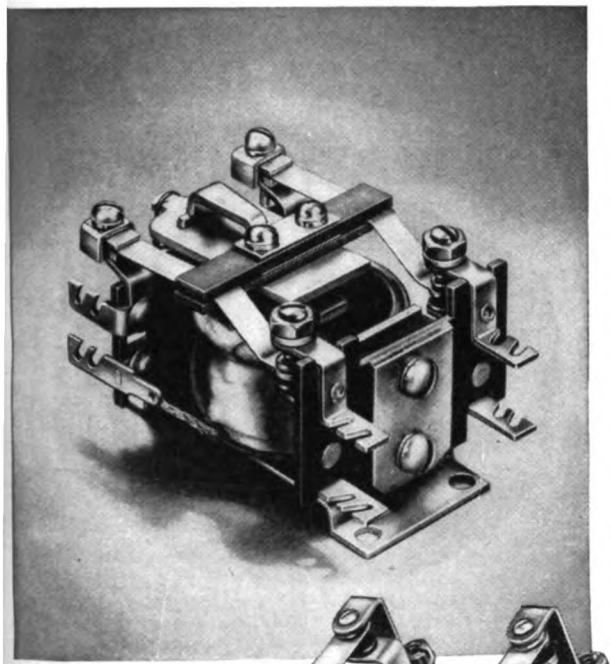
A STANDARD RELAY FOR DOZENS OF SPECIAL APPLICATIONS

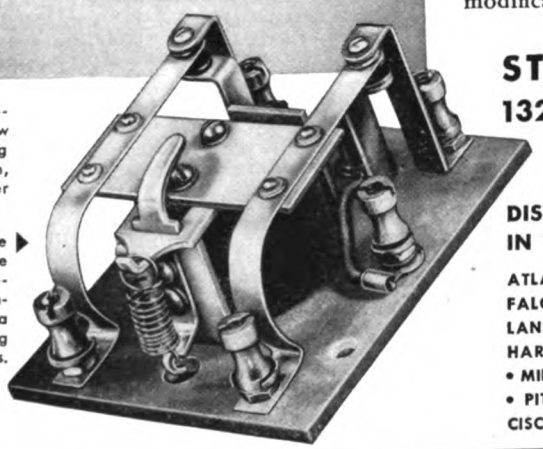
. . . requiring a compact light weight unit that handles plenty of power and is highly resistant to shock and vibration



The design flexibility of Struthers-Dunn 10 Frame a-c and d-c relays coupled with their proven dependability under adverse operating conditions make them ideal for many applications usually requiring more costly special types. 10 Frame Relays are small and light and particularly built to withstand shock and continuous vibration.

Features include: — One- to four-pole, single- and double-throw contact arrangements; insulations suitable for power or radio-frequency circuits; high contact pressures and plenty of "follow-up" for long contact life.

Struthers-Dunn #10 Frame Relays are currently used in many Radar, Radio, and Communications circuits for shipboard, aircraft and general use, including a wide variety of industrial installations requiring extra quality and plus performance. Write for Data Sheet 10-000 describing the 10-Frame Relay Series and outlining a few of the many available modifications.



▲ TYPE 10XBX—Two-pole, double-throw contacts, featuring phenolic insulation, metal base, and solder terminals.

Modified 10 Frame construction Type 10XBX117 for R-F application. Features include bonded mica insulation and binding post type terminals. ▶

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5,312 RELAY TYPES

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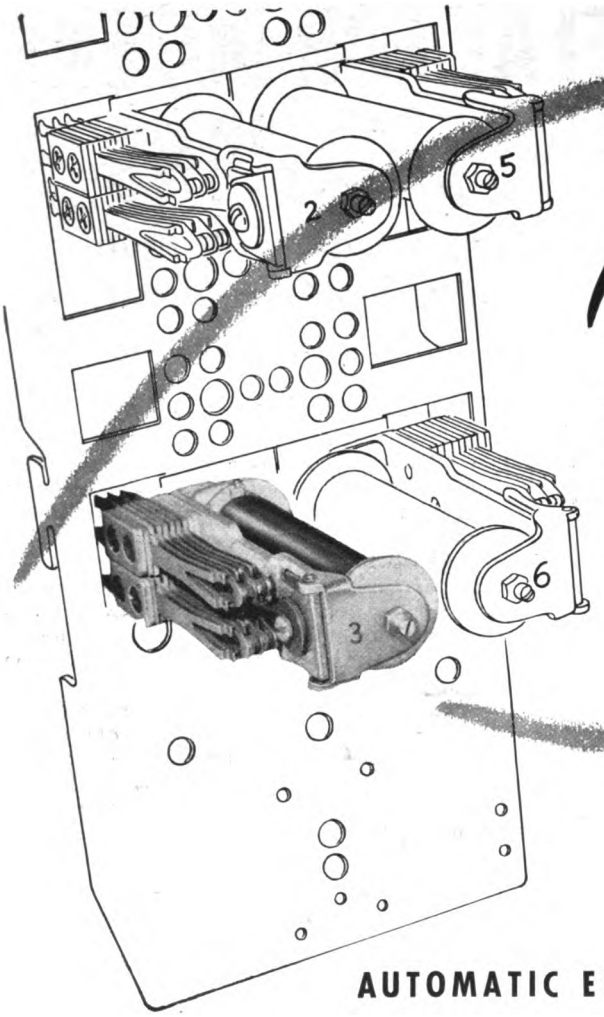

More THAN 300,000,000 OPERATIONS

AUTOMATIC ELECTRIC'S CLASS "B" RELAY

Want real proof of relay ruggedness? Many months ago, several Class "B" relays, taken from regular production, were placed on "life test." Today, with no attention except for occasional lubrication, they are still functioning satisfactorily—and every one has hung up the amazing record of more than 300,000,000 operations! For ruggedness—for all the other features you need, specify Automatic Electric's Class "B" relays.

Independent twin contacts for dependable contact closure... efficient magnetic circuit for sensitivity and high contact pressure . . . unique armature bearing for long wear under severe conditions . . . compact design for important savings in space and weight. Now available for coil voltages to 300 volts DC and 230 volts AC, with capacities up to 28 springs; also with magnetic shielding cover, when specified.

The Class "B" relay, and many others, are shown in Catalog 4071. Write today for your copy.

Relays by **AUTOMATIC ELECTRIC**

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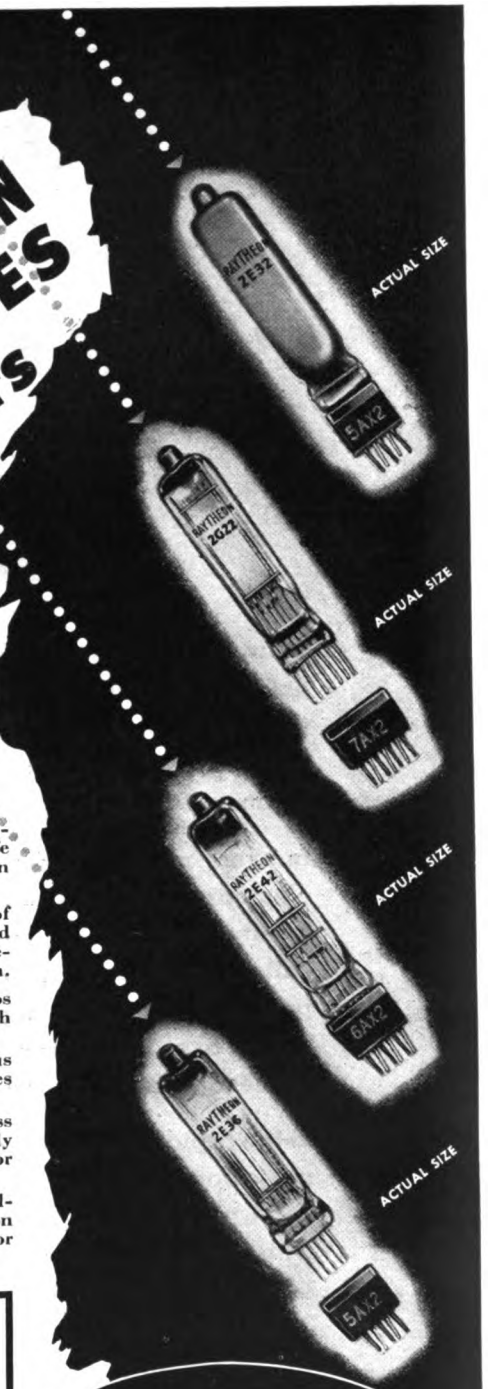
NEW RAYTHEON SUB-MINIATURE TUBES for Pocket Receivers



Since 1938 Raytheon has pioneered in the design, development and production of small, low drain, long life tubes. These have helped to make possible the modern extremely compact hearing aid.

Now for Radio Receivers—Now Raytheon announces a physically similar kit of that style, sub-miniature tubes for radio receiver applications. Included is a shielded RF-pentode amplifier, a triode-heptode converter, a diode-pentode detector-amplifier and an output pentode for earphone operation.

Much Smaller Radios Possible—These tubes make it possible to construct radios a fraction the size of prewar "personals," with sensitivity rivaling much larger sets.

The ratio of performance to battery drain is maintained very high, thus assuring the maximum possible operating life from the small size batteries now available.

The line consists of tubes approximately $1\frac{9}{16}$" long x 0.3" x 0.4" in cross section. Each type is available with pins for use with small commercially available sockets as illustrated, or may be had with long flexible leads for wiring the tube directly into the circuit.

No progressive radio manufacturer will overlook the tremendous possibilities inherent in the small pocket receiver—built around the new Raytheon sub-miniature tubes. But call on Raytheon for *every* tube need—large or small—for the finest in engineering, production and performance.

ELECTRICAL CHARACTERISTICS

	2E31† 2E32# Shielded RF Pentode	2G21† 2G22# Triode-Heptode	2E41† 2E42# Diode-Pentode	2E35† 2E36# Output Pentode
Filament Voltage	1.25 V	1.25 V	1.25 V	1.25 V
Filament Current	50 ma	50 ma	30 ma	30 ma
Max. Grid-Plate Capacitance	0.018 μμf	0.065 μμf‡	0.10 μμf	0.2 μμf
Plate Voltage**	22.5 V	22.5 V	22.5 V	22.5 V
Screen Voltage	22.5 V	22.5 V	22.5 V	22.5 V
Control Grid Voltage*	0	0	0	0
Osc. Plate Voltage	—	22.5 V	—	—
Plate Current	0.35 ma	0.2 ma	0.4 ma	0.27 ma
Screen Current	0.3 ma	0.3 ma	0.15 ma	0.07 ma
Osc. Plate Current	—	1.0 ma	—	—
Transconductance	500 μmhos	60 μmhos (Gc)	400 μmhos	385 μmhos
Plate Resistance	0.35 meg	0.5 meg##	0.25 meg	0.22 meg

*With 5 megohm grid resistance connected to F—.
**Higher voltage operation is possible as shown on engineering characteristics sheet available by request.

†Flexible lead Types.
#Plug-in Types.
##Approximate conversion Rp.
‡Signal grid to mixer plate Capacitance

RAYTHEON
MANUFACTURING COMPANY

Radio Receiving Tube Division
NEWTON, MASSACHUSETTS • LOS ANGELES
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EXCELLENCE IN ELECTRONICS

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CINAUDAGRAPH

designed over 100 different

PERMANENT MAGNETS

FOR

RADAR

Many manufacturers shared in the development of Radar. Skilled scientists in many a research laboratory contributed to the perfection of this remarkably effective instrument for detecting, locating, and defining objects at a distance through fog or storm, in the night.

In every modern Radar Set a permanent magnet is an essential element. We, at Cinaudagraph, feel that it was distinctly a tribute to the skill of our engineers and workmen that we were called upon to design and manufacture a large portion of the permanent magnets for all the Radar Sets. Our engineers designed over 100 different types of magnets, and tens of thousands of these were manufactured in our plant.

In the rapidly developing field of electronics, the permanent magnet is bound to play an important part. Our engineering department will be glad to help on magnet problems in connection with any apparatus or instrument you are planning to produce.

Send for our pamphlet, "Permanent Magnet Design"

2 SELLECK ST. **CINAUDAGRAPH CORPORATION** **STAMFORD, CONN.**

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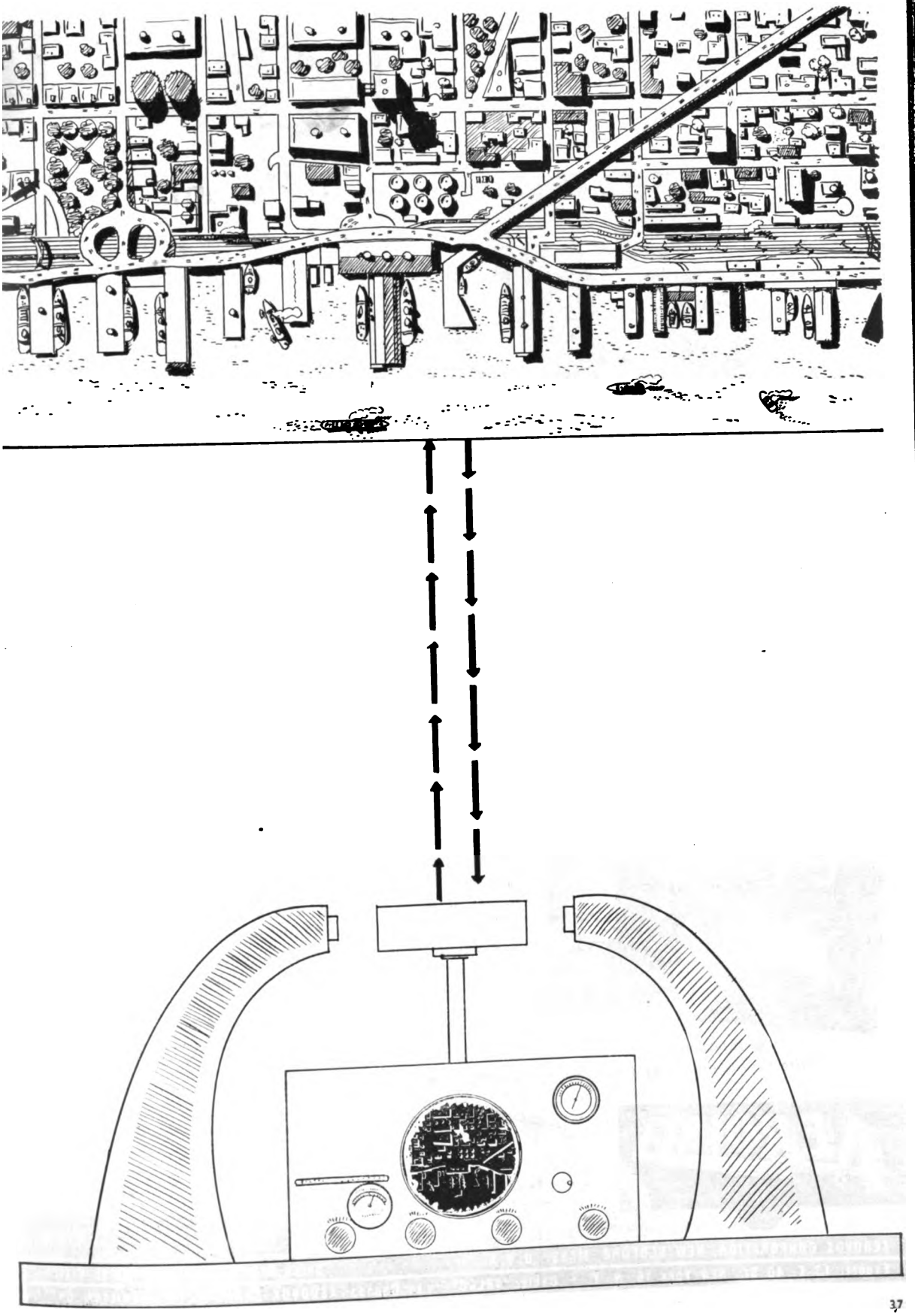

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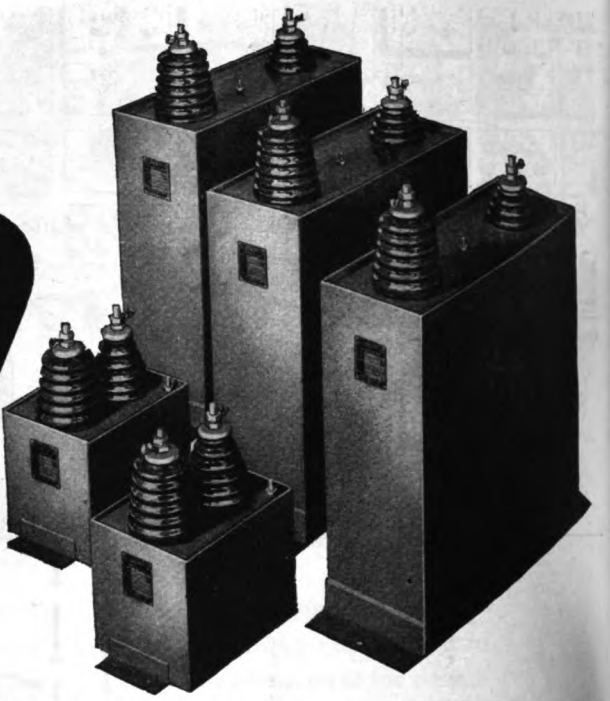
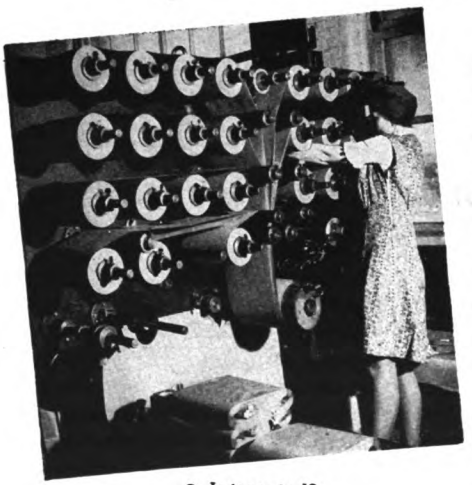
CAPACITOR DREADNAUGHTS





● *Interested?*
Write for detailed literature.

● Outstanding production equipment in the hands of Aerovox craftsmen, accounts for these veritable capacitor dreadnaughts. In exacting services such as radio transmitters, heavy-duty electronic equipment, and in the electric power field, these units have won citation after citation for exceptional ruggedness.

Such ruggedness stems from the Aerovox winding facilities second to none. Special winding machines insure that the multi-layered sections are uniformly and accurately wound under critically-controlled tension. Also, a system of impregnation tanks, pumps and control equipment guarantees the necessary drying after vacuum impregnation that is positively unexcelled by any impregnation process anywhere.

Hermetically-sealed welded steel containers; heavy-duty porcelain insulators; cork gaskets and pressure sealing; nonferrous metal hardware; silver-soldered joints; sturdy mounting means—these are the externals of these capacitor dreadnaughts. Standard listings of Type 20 up to 50,000 v. D.C.W. Capacitances from 0.1 to 10 mfd.

AEROVOX *Capacitors*

INDIVIDUALLY TESTED

AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. · SALES OFFICES IN ALL PRINCIPAL CITIES

Export: 13 E. 40 ST., NEW YORK 16, N. Y. · Cable: 'ARLAB' · In Canada: AEROVOX CANADA LTD., HAMILTON, ONT

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CLAIM STAKING

Hallicrafters and Very High Frequency

Based on the facts in the case, Hallicrafters can stake out a very strong claim to leadership in the very high frequency field. The facts include such things as the Model S-37, FM-AM receiver for very high frequency work. The Model S-37 operates from 130 to 210 Mc.—the highest frequency range of any general coverage commercial type receiver.

Hallicrafters further supports its claim to domination in the high frequency field with the Model S-36A, FM-A M-CW receiver. The 36A operates from 27.8 to 143 Mc., covers both old and new FM bands and is the only commercially built receiver covering this range.

Further developments in this direction can soon be revealed—adding further support to Hallicrafters claim to continued supremacy in the high frequency field.

HALLICRAFTERS NEW $600,000 HOME NOW UNDER CONSTRUCTION.

hallicrafters RADIO

THE HALLICRAFTERS CO., MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT • CHICAGO 16, U. S. A.

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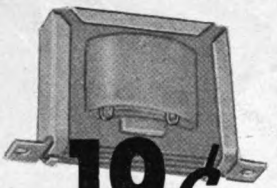
Both are FERRANTI



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from THE LOWEST PRICED TRANSFORMER to

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HIGH QUALITY
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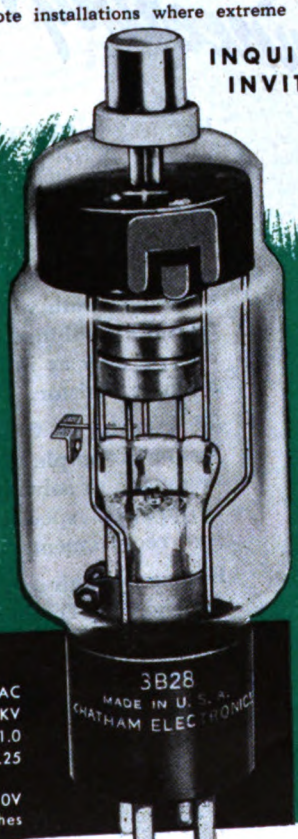
Two rectifiers with citations for

RUGGEDNESS!

NOW AVAILABLE FOR PEACETIME APPLICATIONS

These rugged Chatham rectifiers offer proven dependability under severe operating conditions. Xenon gas fill results in heavy current capacity, low voltage drop, and high peak inverse voltage rating. Another feature is very wide ambient temperature range. Chatham engineering provides immunity to shock and vibration. Both types are especially applicable to mobile, airborne and remote installations where extreme temperature ranges are encountered. Types 3B28 and 4B32 operate dependably, and without auxiliary heaters, within a temperature range of −75°C to +90°C. All ratings are conservative and ample overload capacity prevents failure under accidental overload. Further details will be furnished promptly on request.

INQUIRIES INVITED



TYPE 3B28:

Filament Volts	2.5AC
Peak Inv. Volts	10.0KV
Peak Anode Amps	1.0
Aver. Anode Amps	0.25
Voltage Drop Approx.	10V
Height	6.38 Inches

TYPE 4B32:

Filament Volts	5.0AC
Peak Inv. Volts	10KV
Peak Anode Amps	5.0
Aver. Anode Amps	1.25
Voltage Drop Approx.	10V
Height	7.88 Inches

CHATHAM ELECTRONICS

475 WASHINGTON ST., NEWARK 2, NEW JERSEY

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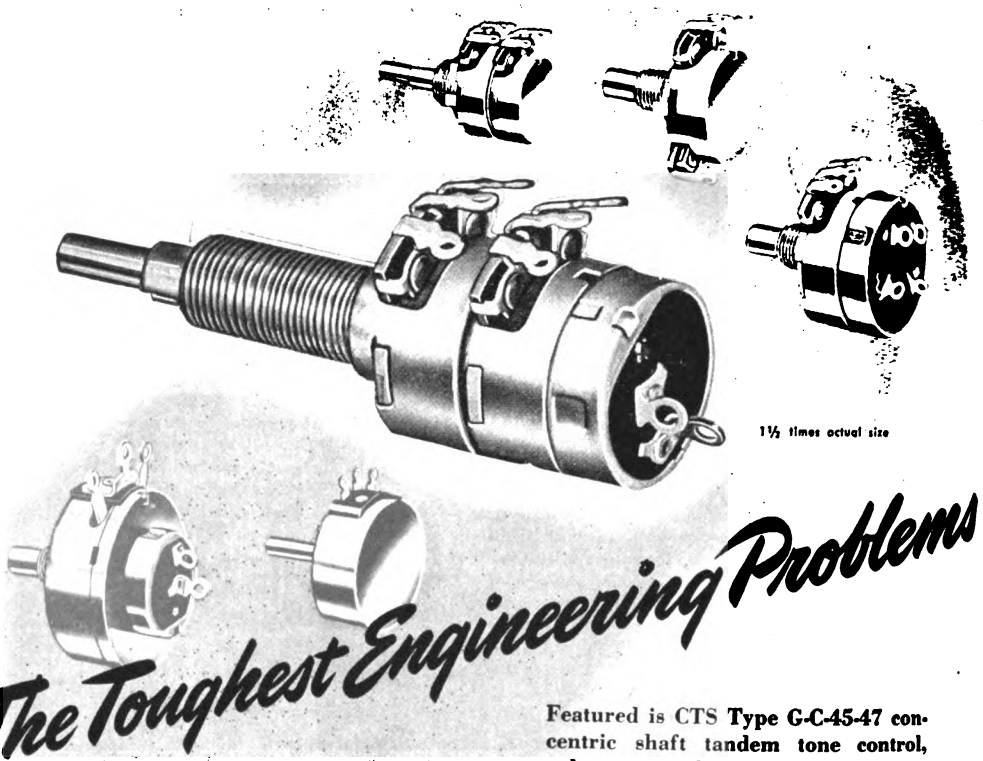

1½ times actual size

The Toughest Engineering Problems

Featured is CTS Type G-C-45-47 concentric shaft tandem tone control, volume control and off-on switch. This resistor was specially designed for use where panel space is limited and the going is rough—as in auto radios, for example. Both volume and tone controls are combined in this resistor and occupy only as much panel space as a single resistor.

This featured G-C-45-47 resistor is just one example of the ability of CTS engineers to solve new problems . . . to provide special adaptations for new requirements.

Electronic engineers all over the world depend on CTS for:

- A resistor engineered for the application.
- Uniform quality throughout the shipment.
- Each resistor carefully tested to assure top performance.
- Delivery when promised.

Call on CTS specialists for aid in solving *your* variable resistor problems.

REPRESENTATIVES

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Phone: Logan 7495

Frank A. Emmet Co.
2837 West Pico Boulevard
Los Angeles 6, California
Phone: Rochester 9111

George A. Coleman
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San Francisco 11, Calif.

BRANCH OFFICES

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CHICAGO TELEPHONE SUPPLY
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ELKHART ★ INDIANA

VARIABLE RESISTORS AND ASSOCIATED SWITCHES

Manufacturers of Quality Electro-Mechanical Components Since 1896

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F M too —
e Same TEMCO Team
ll continue to SET DELIVERY RECORDS

Bendix Radio

DIVISION OF BENDIX AVIATION CORPORATION

BALTIMORE 4, MARYLAND

August 3,1945

Mr. M. B. Kahn
Transmitter Equipment Mfg. Co.
345 Hudson Street
New York-14, New York

Dear Mr. Kahn:

May we take this opportunity of expressing our appreciation and thanks for the efficient manner in which your firm has handled our orders for subcontracted items on the MPG equipment.

Your Company, by the all-out effort of yourself, your subordinates, and your personnel, have consistently met the requirements under the most trying conditions possible.

You are to be complemented on the flexibility and versatility of your operation. This has enabled you to put into effect with a minimum of effort the many changes necessary without jeopardizing our delivery requirements.

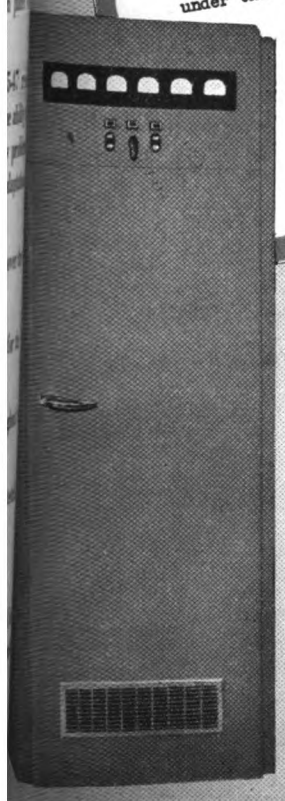
We have been advised that this is the first radar equipment ever ordered by the Army on which the schedules have been consistently met. For this also, we can thank TEMCO as you are building about seventy per cent of all the electrical components used on this contract.

In conclusion, may we convey our appreciation and thanks to the officers, supervisors and personnel of TEMCO for a job well done under the most trying conditions.

Cordially yours,

BENDIX RADIO, Division of
Bendix Aviation Corporation

R.A.Anderson
Procurement Manager



Improved
F M Broadcasting Equipment
NOW Being Produced by
TEMCO'S
Microwave Radar Technicians

NEW MODEL 250 BCF
NOW IN PRODUCTION

Normal Rated Output 250 Watts
Maximum Rated Output 375 Watts

Features...

- New miniature high frequency tubes permitting high efficiency and perfect shielding.
- Newly designed amplifier circuit completely eliminating tank radiation, feedback and radio frequency potentials from transmitting frame.
- Built-in center frequency deviation meter calibrated directly in cycles.
- Frequency range of 88-106 megacycles.
- Frequency stability ± 1500 cps or better of assigned center frequency.
- Audio frequency response ± 1½ db 30-16000 cps (after deemphasis).
- Audio distortion 50-16000 cycles less than 2% RMS.
- Noise level FM db below ± 75 Kc swing.
- Noise level AM 70 db below 100% modulation.

Write for complete descriptive data, prices and information for filing with FCC for license application.

TEMCO

RADIO COMMUNICATION EQUIPMENT

TRANSMITTER EQUIPMENT MFG. CO., INC.

345 Hudson Street, New York 14, N. Y.

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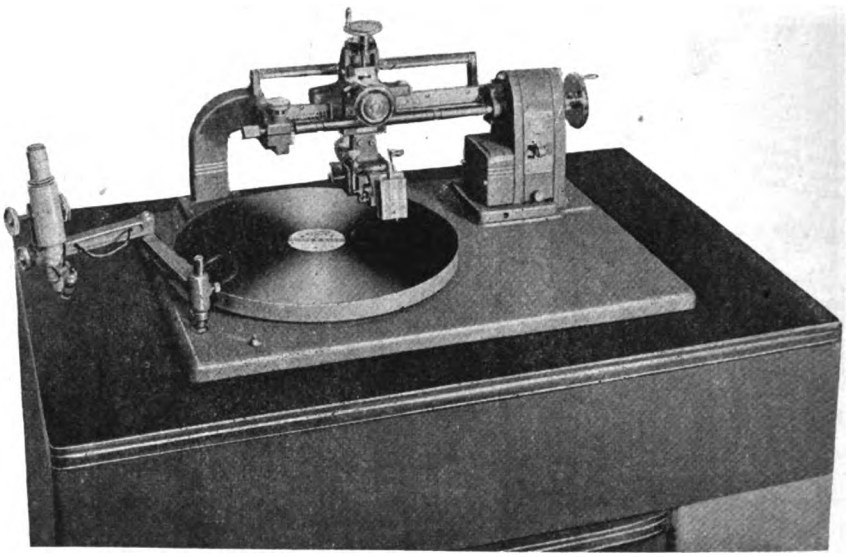
PRESTO-1946

A PREVIEW OF THE *NEWEST* PRESTO RECORDER



Presto's new 14A Recorder herewith makes its bow to all major radio stations, recording companies and motion picture studios. In presenting this model for the first time, Presto offers many new features that are fully described on Page One of Presto's postwar catalog. Send for Page One today.

PRESTO
RECORDING CORPORATION
242 West 55th Street, New York 19, N. Y.
Walter P. Downs, Ltd., in Canada

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS

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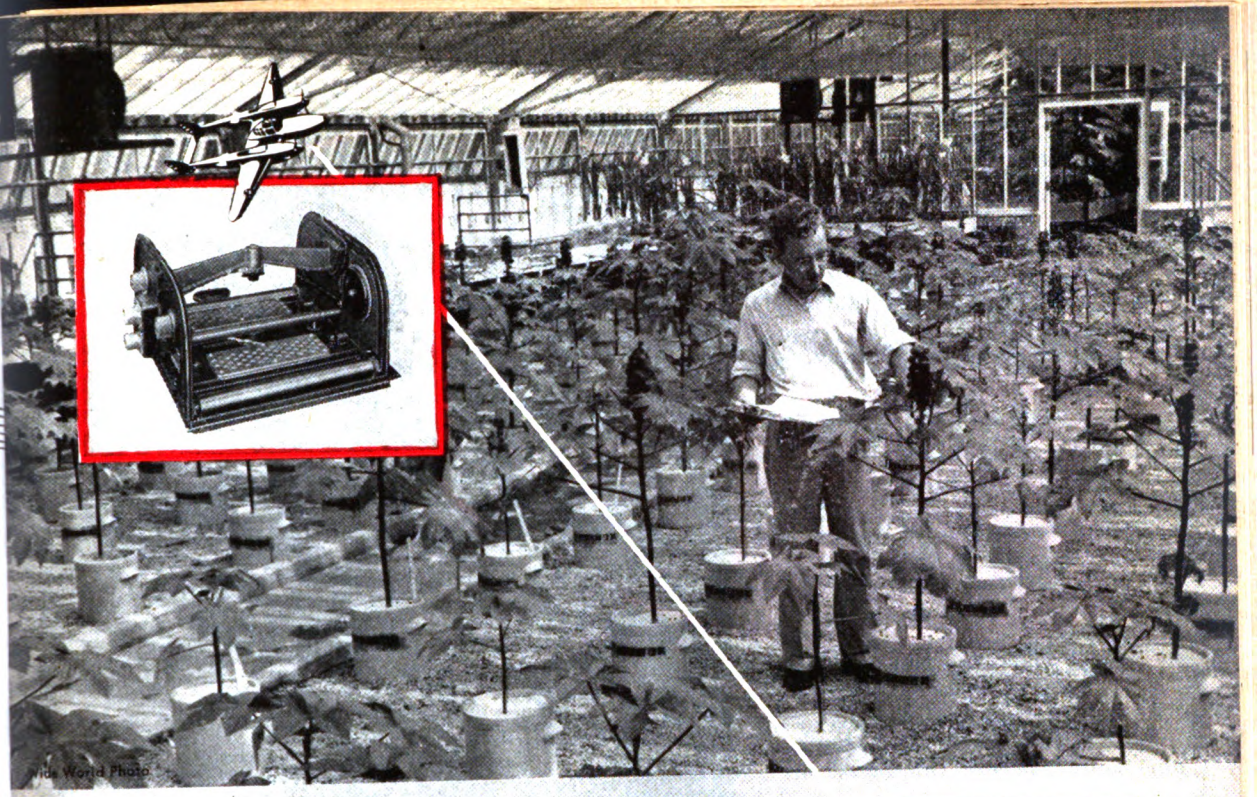

TURN ON THE HEAT

when and where you want it . . .

. . . with NICHROME*

In addition to toasters, electric irons, radiant heaters, stoves, etc., the uses for electrical heating elements have multiplied into an almost endless list of new and novel applications during the war.

From keeping aerial cameras warm in the stratosphere to protecting delicate roots underground, Nichrome heating elements have been impressed into service to deliver dependable heat . . . *wherever* and *whenever* it is required.

In all of these applications the vital factor of dependability leaves no room for compromise with quality.

For this reason and because Nichrome insures long heater life and close control over wide temperature range, it has been specified for *more new electrical heating applications than any other alloy resistance wire.*

Although there are several excellent Nickel-Chromium combinations there *is only one* NICHROME and it is *made only by* Driver-Harris. For improved performance and longer life in your new products, specify Nichrome and other resistance alloys by Driver-Harris. Tell us what you need.

*Trade Mark Reg. U. S. Pat. Off.

NICHROME
is made *only* by

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SPECIAL PURPOSE ALLOYS SINCE 1905

Driver-Harris
COMPANY
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BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle

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LET US DEMONSTRATE WHAT ELECTRONIC HEATING can do for YOU

PROOF BY TRIAL . . . that's our motto. Before you invest in electronic heating equipment you should be shown how any process requiring heat can be done *better, faster* and *more economically* for you with a Scientific Electric unit.

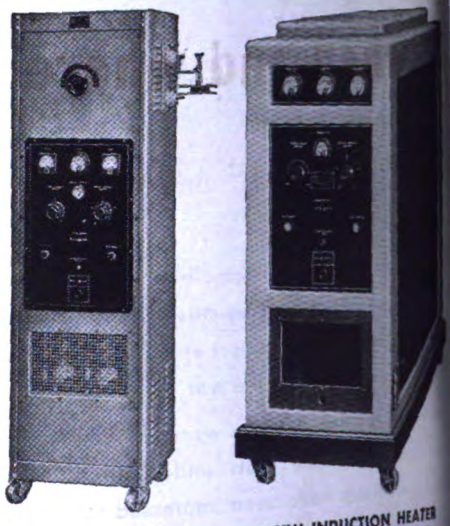
Our engineers will gladly—*without obligation*—make a study of the heating process under consideration. They will then make recommendations supported by practical demonstrations on the S.E. heater best suited for the job.

This procedure will enable you to figure accurately the economies that will result; also permit you to estimate the time required to pay for the equipment out of resultant savings.

You can submit your heating problems to us with the assurance that absolute secrecy will be observed, if so desired. Investigate the advantages of applying electronic heating in your manufacturing operations NOW. Consult with us at your earliest opportunity.

Write for free copy of
The ABC of Electronic Heating

Manufacturers of
Vacuum Tube and Spark Gap Converters Since 1921



3 KW DIELECTRIC HEATER
Dielectric Heating Units priced from **$1500.**
(3 KW complete)

5 KW INDUCTION HEATER
Induction Heating Units priced from **$1285.**
(for 5 KW complete with 1 work coil)

Scientific Electric Electronic Heaters are made in the following range of power; 3—5—7½—8—10—12½—15—18—25—40—60—80—100—250 KW. — and range of frequency up to 300 Megacycles depending on power required.

Scientific Electric

DIVISION OF "S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE ST. GARFIELD, N. J.

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- PRECISION WIRE WOUND RESISTORS
- WHEATSTONE BRIDGES
- RADIO & ELECTRONIC TEST EQUIPMENT
- RADAR ASSEMBLIES

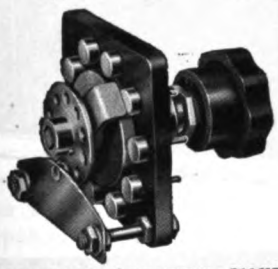
Eastern Electronics Corp.

PHONOGRAPH TURNTABLE UNIT

The need at this time for large quantities of phonograph turntable assemblies has prompted us to quickly design and tool up for the immediate production of this item. Engineers will find this compact turntable meeting all of their requirements for performance. We are prepared to make immediate deliveries and suggest that purchasing agents place their orders at once.

PERFORMANCE: — Correct and uniform speed is secured through the use of a motor of ample capacity, preloaded to operate on the flattest portion of the torque-speed characteristic.

★ ★ ★



ROTARY SELECTOR SWITCH

Designed for use where low contact resistance and mechanical sturdiness is required. Its construction insures long wear with low contact resistance of less than .001 ohm. May be arranged to have several sections to obtain multi-polar switching.

Well suited for precision test instruments; shunt ammeters, thermo-couple types, Wheatstone Bridges, and similar devices.

Korect-Ohm Precision Wire Wound Resistors

General Specifications

KORECT-OHM Resistors are wound on a sectional Ceramic bobbin, the direction of the winding being alternated on each section so that the resistor is non-inductive. Resistors can also be inductively wound when required.

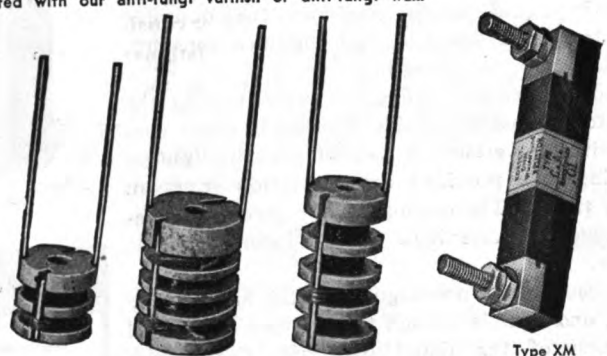
To insure stability Korect-Ohm Resistors are aged and treated to relieve strains due to winding before the final adjustment is made.

Final resistance adjustment to an accuracy of better than .1%.

TEMPERATURE COEFFICIENT. Resistors are wound with selected alloy wire having a resistance change vs. temperature of less than .08% between —55 degree C and plus 55 degree C.

IMPREGNATION. A radically new material, INSO-FLEX, used for impregnating Korect-Ohm resistors has been developed by our engineering laboratory. This new material has several outstanding advantages, being extremely flexible it does not chip nor crack due to expansion or contraction under temperature variations. INSO-FLEX has high insulating qualities and is highly resistant to alkalies and weak acids, is resistant to moisture and mechanical shock. It forms an intimate bond between the ceramic bobbin, winding and lead wires. Being flexible, the lead wires may be bent and formed without disturbing the moisture-proof bond between the lead wires and INSO-FLEX covering.

Korect-Ohm resistors can also be supplied impregnated with our anti-fungi varnish or anti-fungi wax.



Type C
Maximum resistance 500,000 ohms.

Type A
Maximum resistance 1,000,000 ohms.

Type B
Maximum resistance 1,000,000 ohms.

Type XM
Instrument resistance shunt .1 ohms or lower. 25 watts.

We will make special resistors to any value or tolerance.

Our Regular Line of Resistors are ready for delivery.

Eastern Electronics Corp.

41 CHESTNUT STREET, NEW HAVEN, CONN.

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ELECTRONICS DESIGNER'S

HERE 3 CAPACITORS DO TWICE THE WORK OF 25

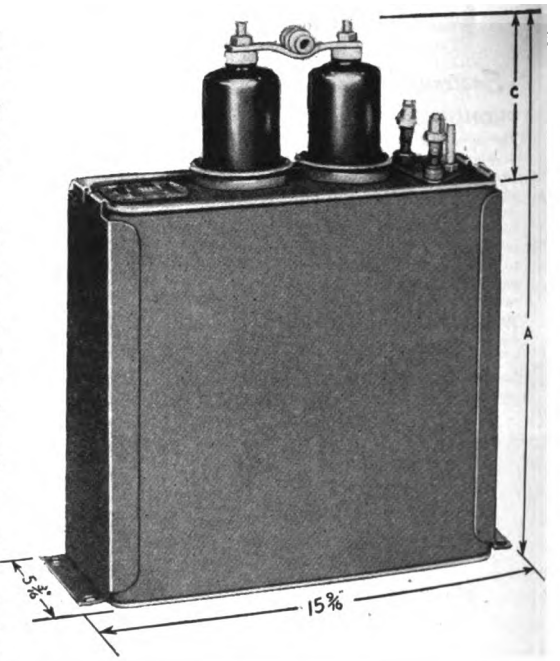
A MANUFACTURER of induction heaters replaced 25 mica capacitors in his resonant (tank) circuit with three General Electric HFP parallel-plate, water-cooled capacitors. He saved nearly half the cost and space, and more than doubled the kva. Result: a more compact, more powerful, and more efficient heater.

Class HFP capacitors, with their two sets of heavy, sheet-aluminum plates, are specifically designed for use in resonant circuits of high-frequency oscillators, such as those employed in electronic heaters. Outstanding features of Class HFP capacitors are compact construction, and ability to operate at high voltages and to carry heavy continuous currents at frequencies from 50 kilocycles up into the megacycles. The special dielectric is a new, stable, synthetic liquid which combines the desirable characteristics of low loss, high dielectric constant, and high dielectric strength.

A coil of copper tubing, for water-cooling the capacitor, is installed inside the case in direct contact with the grounded pair of capacitor plates. Couplings are provided for connection to 3/8-in. copper tubing. The cooling feature permits a compact assembly and high current rating per unit volume.

The cases are of nonmagnetic metal, hermetically sealed, and flexible enough to take care of thermal expansion of the liquid dielectric. Capacitance tolerance is from plus 5 per cent to minus 5 per cent of the rated capacitance at 25 C; Q factor is above 2000 for full load operation at frequencies from 50 kilocycles to one megacycle. Internal inductance is low, which gives resonant frequencies from 3 to 9 megacycles, depending upon the capacitance rating. Write for Bulletin GEA-4365. *Apparatus Dept., General Electric Company, Schenectady 5, N. Y.*

Keep on buying BONDS—and *keep all you buy*



CLASS HFP HIGH-FREQUENCY, PARALLEL-PLATE, WATER-COOLED CAPACITORS

Maximum Permissible Rms Working Voltage	Microfarad Rating	Maximum Permissible Rms Working Current in Amp at 540 Kilocycles	Approximate Dimensions in Inches	
			A	C
2000	0.025	170	16 7/32	2 1/2
	0.030	204		
	0.034	230	16 7/32	2 1/2
3000	0.0165	168		
6000	0.0075	153	18 7/16	4 7/16
	0.01	204		
6600	0.009	202	18 7/16	4 7/16
	0.0029	88		
9000	0.005	153	18 7/16	4 7/16
	0.0056	171		

GENERAL ELECTRIC

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DIGEST

LIGHT-WEIGHT TRANSFORMERS

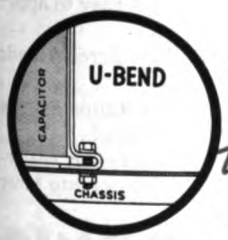
for tight spots

When size and weight are important and weather resistance isn't, G-E core-and-coil transformers solve a lot of electronic-design problems. Uniform coils, automatically wound over the finest-grade core laminations, are of the same high quality and give the same reliable performance as G-E cased transformers.

Standard core and coil units include 60 types and ratings of plate transformers, 106 filament transformers, 34 plate-and-filament transformers, and 61 reactors. Ratings up to 50 kva (physical size) are wound on standard laminated cores; larger units can be built from special parts. Write for Bulletin GEA-4280.

Small ONLY IN *Size*

Inside these G-E small panel instruments are packed accuracy and reliability usually associated with larger G-E instruments. They have space-saving internal-pivot construction. They respond quickly. Accurate readings are easily made. The instrument weighs a mere 3 ounces and is just 1½ inches wide and less than 1 inch deep. Either watertight or conventional construction is available for direct-current, audio-frequency and radio frequency applications. Write for Bulletin GEA-4380.



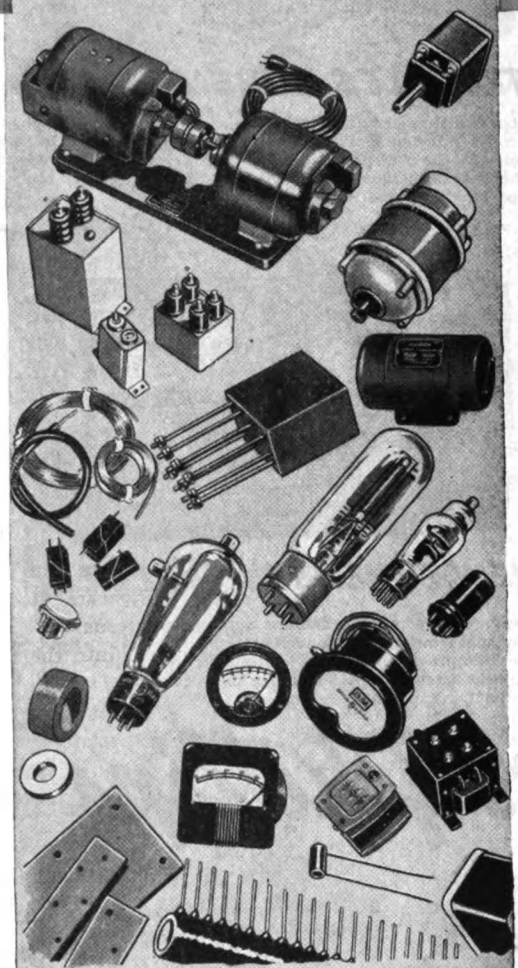
BRACKETS

that hold their own

A distinct advance in bracket design simplifies the mounting of rectangular-cased G-E capacitors. A U-bend replaces the conventional L-shape and provides a spring-washer effect for secure capacitor mounting. At the same time, it reduces strain on both capacitor and chassis, and compensates for tolerances in capacitor case heights.

For either base or inverted mounting, U-bend brackets are available for most G-E rectangular-case a-c and d-c capacitors. Write for Bulletin GEA-4357.

Timely Highlights on G-E Components



Capacitors • Sensitive control and time-delay relays • Limit switches • Motors, dynamotors, amplidynes • Motor-generator sets • Alnico magnets • Small panel instruments • Formex* magnet wire • Radio transformers • Switchettes • Selsyns • Chokes • *also tubes, crystals, plastics products, insulation materials, and many others*

General Electric Company
Apparatus Dept., Sec. 642-10
Schenectady 5, N. Y.

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..... GEA-4365	..... GEA-4280
..... GEA-4380	..... GEA-4357

NAME.....

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CITY..... STATE.....

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TROUBLES SUBSIDE

It was a slow and troublesome job to drive small slotted screws in fastening a pressed fabric panel on this electrical relay for the P-80 Jet Plane. Frequent driver skids gouged the special fungus-resistant varnish, forced disassembly and junking of marred panels.

OUTPUT HITS STRIDE

Assembly of this part was speeded up 400% when a change was made to Phillips Recessed Head Screws. Fumbling was ended, and a spiral driver could be used, permitting faster driving. Driver skids were eliminated, along with waste of parts and time for disassembly and reassembly.

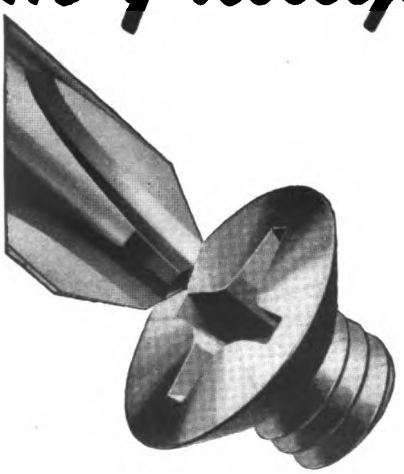
NEW STRENGTH SUPPLIED

Design engineers favor Phillips Screws, because they not only speed output and reduce costs . . . they also permit design improvements that add strength, often with the use of fewer screws. This advantage is especially evident in compact, complicated assemblies.

SHOW IT WITH PRIDE

Wherever screw heads are exposed, the Phillips Recess adds a sales advantage. No unsightly burrs to snag clothing or nick fingers – and sidetrack sales! Its ornamental design blends with modern contours – and it needs only a quarter turn to line up – looks well in any position.

It's Phillips — the engineered recess!



In the Phillips Recess, mechanical principles are so correctly applied that every angle, plane, and dimension contributes fully to screw-driving efficiency.

. . . It's the exact pitch of the angles that eliminates driver skids.

. . . It's the engineered design of the 16 planes that makes it easy to apply full turning power – without reaming.

. . . It's the "just-right" depth of recess that enables Phillips Screw Heads to take heaviest driving pressures.

With such precise engineering, is it any wonder that Phillips Screws speed driving as much as 50% – cut costs correspondingly?

To give workers a chance to do their best, give them faster, easier-driving Phillips Recessed Head Screws. Plan Phillips Screws into your product now.

PHILLIPS Recessed Head SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

Made in all sizes, types and head styles

25 SOURCES

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The Corbin Screw Corp., New Britain, Conn.
General Screw Mfg. Co., Chicago, Ill.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
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Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N.Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
The Steel Company of Canada Ltd., Hamilton, Canada
Wolverine Bolt Co., Detroit, Mich.

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Dieflex Varnished Tubing Products are made of closely braided sleevings completely impregnated and treated with special insulating varnishes. A smooth inside bore to prevent snagging, uniformity of size, complete roundness, maximum flexibility, and excellent ageing qualities are found in all Dieflex products. They do not fray or pinch when cut.

Cotton or Fiberglas Base Tubings and Sleevings—Dieflex Varnished Tubing Products are made both with cotton base or glass base braided sleevings in all standard grades and sizes.

Dieflex Varnished Tubing Products—both cotton and Fiberglas base—are made to meet and surpass the V.T.A. and A.S.T.M. standards. Grade A-1 Magneto quality, Grade B-1 Radio quality varnished tubings, and Grades C-1 Extra Heavily Coated, C-2 Heavily Coated, and C-3 Lightly Coated Saturated Sleevings are "tops in quality."

Silicone Treated Fiberglas Tubings and Sleevings are also now available. These are made by impregnating and treating Fiberglas Sleevings with the latest Dow Corning high temperature resins.

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OTHER IMC PRODUCTS—Vortex Varnished Cloth and Tapes—Varsiot Combination Slot Insulation—Varnished Silk and Paper—Fiberglas Electrical Insulation—Manning Insulating Papers and Pressboards—Dow Corning Silicones—Pedigree Varnishes—Hard Vulcanized Fibre and Fishpaper—Laminated Bakelite—Adhesive Tapes—Asbestos Woven Tapes and Sleevings—Cotton Tapes, Webbings, Sleevings, Wood Wedges, and other insulating materials.

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Must we go back?

The evolution of electronics will always remain a bright page in the history books of science. And the record has been significantly brilliant during the past four years when improvements and developments were advanced at a faster rate than normal. With the ending of the war, there may be a few who do not feel the urgency to progress at a similar pace . . . who will be willing to relax the rigid wartime standards. Or there may be those who do not too accurately gauge the temper of the consumer, now in a mood to anticipate only the best from an industry which has accomplished such miracles in the past few years.

Along with many other far-sighted producers, we here at Marion fully intend to maintain our wartime quality pattern, and to cooperate in every known way to provide even better products for a peaceful world. We endorse the postwar standardization program of the Army and Navy Electronics Standards Agency, and will continue to manufacture all Marion electrical indicating instruments in conformity with JAN specifications. Our customers have a right to expect nothing else.

It is important to note that continued adherence to the Electronics Standards Agency program need not result in increased costs, either to the manufacturer or the consumer . . . while it will definitely result in improved product performance wherever such standardized components are used.

We, the manufacturers, engineers, consumers of electronics, are part of a vital, daring, visionary industry. It is with this realization that we are faced with the responsibility of deciding, at this time, whether we can relax, or whether we shouldn't give as much to a world at peace as we gave to a world at war.

Your comments will be welcomed.

MARION ELECTRICAL INSTRUMENT CO.
MANCHESTER, NEW HAMPSHIRE
EXPORT DIVISION 458 BROADWAY · NEW YORK 13, N.Y., U.S.A.
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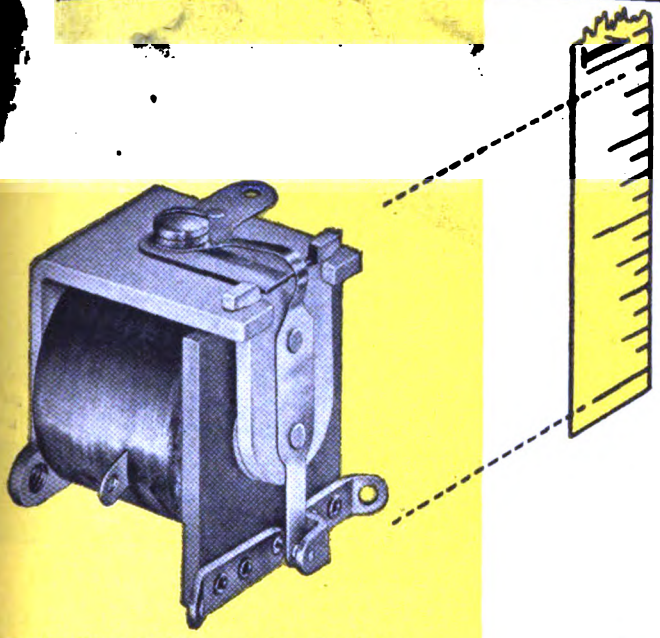
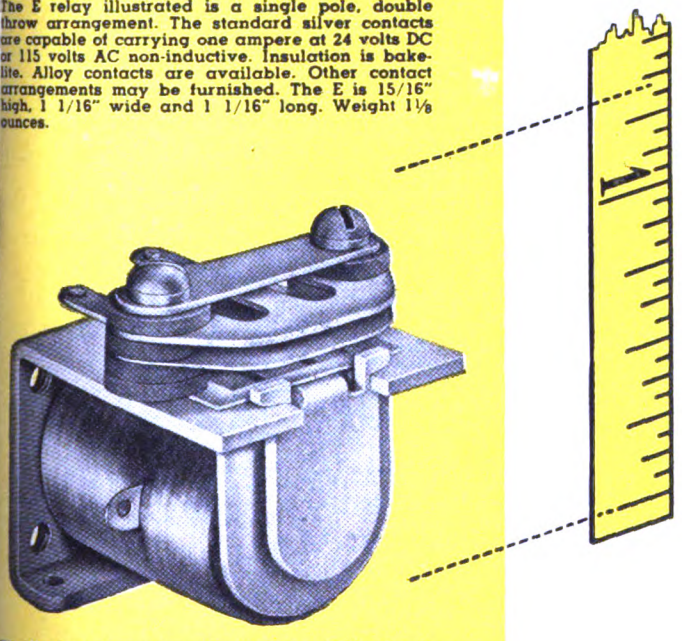
COMPACT CONTROLS with Allied's "E" and "F" Relays



The E relay illustrated is a single pole, double throw arrangement. The standard silver contacts are capable of carrying one ampere at 24 volts DC or 115 volts AC non-inductive. Insulation is bakelite. Alloy contacts are available. Other contact arrangements may be furnished. The E is 15/16" high, 1 1/16" wide and 1 1/16" long. Weight 1⅛ ounces.



The F relay shown is a single pole, single throw normally open combination. The standard contacts carry three amperes at 24 volts DC or 115 volts AC non-inductive. Bakelite insulation is used. May be supplied on other contact combinations. Silver is standard contact material, alloy contacts can be substituted. The F is 1 11/32" high, 1 3/16" wide and 1 3/32" long. Weight is 1⅞ ounces.

DESIGNED for electronic controls in which space limitation is a critical factor, the E relay is small enough to fit into an area of approximately one cubic inch. Light too, it weighs about one ounce. The F relay, although available in two pole, double throw, is only slightly larger and weighs less than two ounces.

Used in your electronic assembly these relays will save you space and weight. Moreover you will be assured of positive and quiet operation, for into these relays go the same careful design and manufacturing precision found in Allied's larger relays.

Whatever your relay applications, check with Allied. In addition to sensitive, telephone, power, differential and other types of relays Allied manufactures solenoids and electro-magnetic devices. A number of strategically located plants are available to supply your immediate requirements. Allied's quality standard is in keeping with your post war products . . . write today for more information.

ALLIED CONTROL COMPANY, INC.

GENERAL OFFICES: 2 East End Ave. (at 79th St.) New York 21, N. Y. Factories: New York City (2 East End Ave.) — Plantsville, Conn. Chicago—4321 N. Knox Avenue, Chicago 41, Illinois. In California, Allied Control Co. of California, 1633 South Hope St., Los Angeles 15, Calif.

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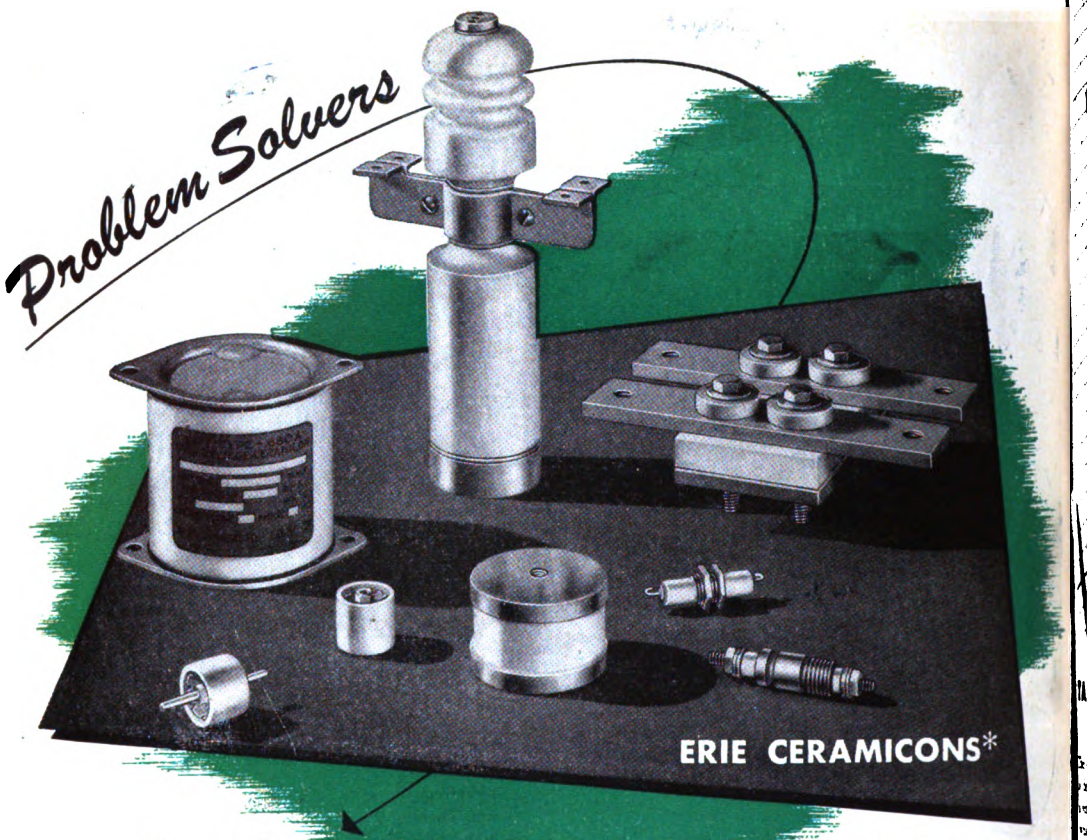

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WITH the growing importance of electronic heating and television, design engineers can find the solution to many of their capacitor problems in Erie Ceramicons.

These silvered-ceramic condensers offer advantages because of their low inductance at high frequencies and extremely simple construction that eliminates circulating currents tending to reduce power ratings. Design is further simplified by the fact that where required, corona shields are incorporated directly into the ceramic dielectrics.

Erie Resistor has developed a number of High Voltage and High KVA Ceramicons of special design and several standard styles are now in production. Included in the above group is a specially designed 30,000 volt feed-thru Ceramicon; a dual filament by-pass unit having conductors to carry 325 amps. The standard Erie Resistor High Voltage ceramic condensers shown include two styles of double cup Ceramicons; a new double cup unit for television power supply filtering, rated at 500 MMF and 10,000 volts D. C.; two High Voltage feed-thru Ceramicons; and a High KVA, High Voltage, multiple plate condenser comparable in size to mica type CM75 but particularly adapted to use at very high frequencies.

Write for data sheets on standard Erie Ceramicons for television and electronic heating applications. You are invited to make use of our extensive knowledge and background for the development of special Ceramicons for these applications.

*CERAMICON IS THE REGISTERED TRADE NAME OF SILVERED CERAMIC CONDENSERS MADE BY ERIE RESISTOR CORPORATION.

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Electronics Division

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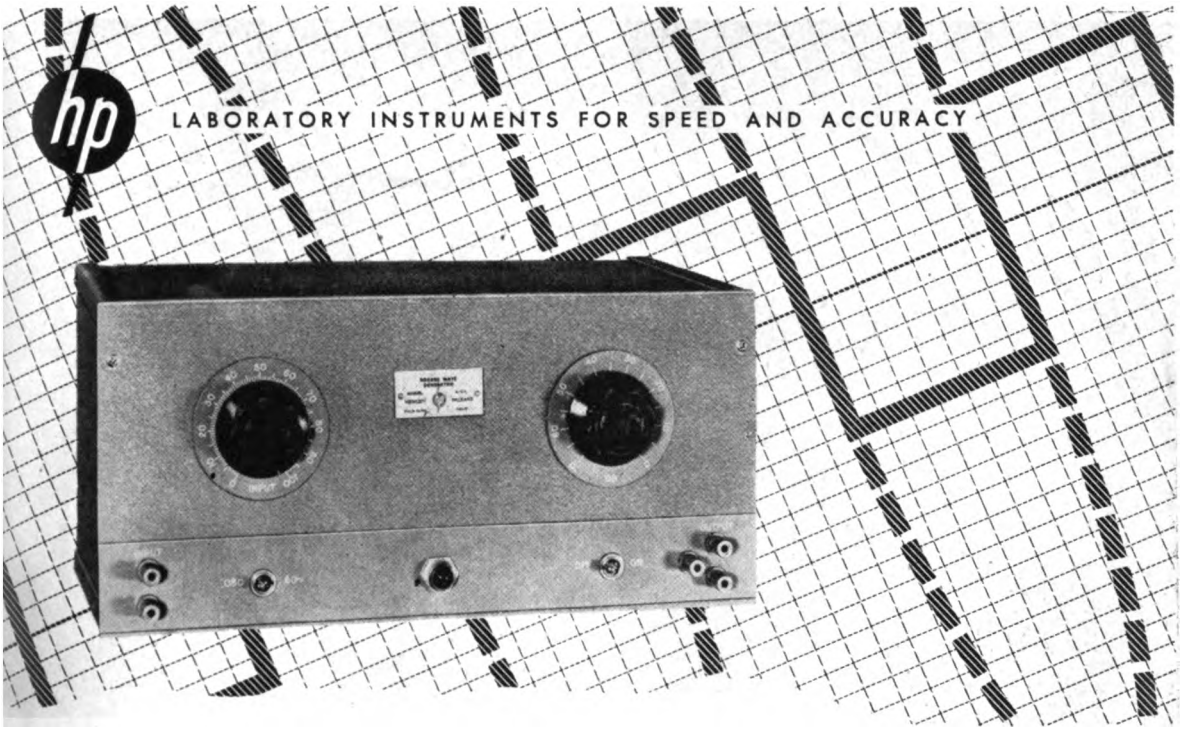

TAILOR-MADE WAVES FOR RAPID TESTING

The *-hp-* Model 210A Square Wave Generator is designed to amplify and clip the tops of a sine wave, and thus convert it into a wave which has vertical sides and a flat top. When the square wave voltage is applied to the amplifier or network under test, the shape of the output wave immediately shows up any distortion.

In production testing, one or two observations with an *-hp-* Square Wave Generator will accurately check the frequency response. In development work, the *-hp-* Model 210A shows up phase shift and transient effects, both of which are difficult to study by other methods.

In practice, a wave which appears to be perfectly square will contain 30 or more harmonics; and when the amplitude or phase relation of the harmonics is disturbed, the square wave will be distorted. (See Fig. 1.) Thus the application of a square wave to a circuit shows up any irregularities in amplitude or phase transmission of that circuit, not only at the square wave frequency, but also at frequencies far removed from the test point. These characteristics are particularly important in television video amplifier work.

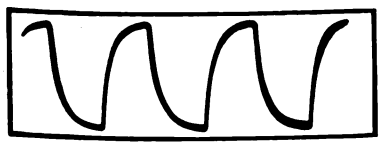

Fig. 1—Shows the square wave distortion caused by poor high frequency response

The output of the generator is square within 1 percent over the frequency range from 20 cps to 10,000 cps; a relatively square wave can be obtained even at 100 kc. The frequency response of the attenuator is sufficiently wide so that the output wave shape is not affected even at the highest frequencies. Once proper criteria have been established, the *-hp-* Model 210A Square Wave Generator is the modern, rapid means of production testing, with the speed and accuracy which are characteristic of all *-hp-* instruments.

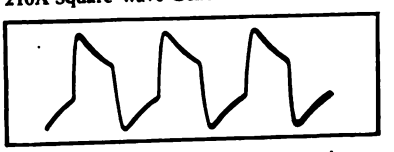

Fig. 2—Low frequency phase distortion serious in television video circuits

Write for complete details on the Model 210A. Ask for *-hp-* Catalog No. 17B, which includes much valuable information on development and measurements.

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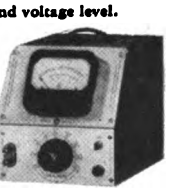

VACUUM TUBE VOLTMETER MODEL 400A

Makes accurate voltage measurements from 10 cycles to 1 megacycle, covers nine ranges, (.03 volts to 300 volts) with full scale sensitivity.

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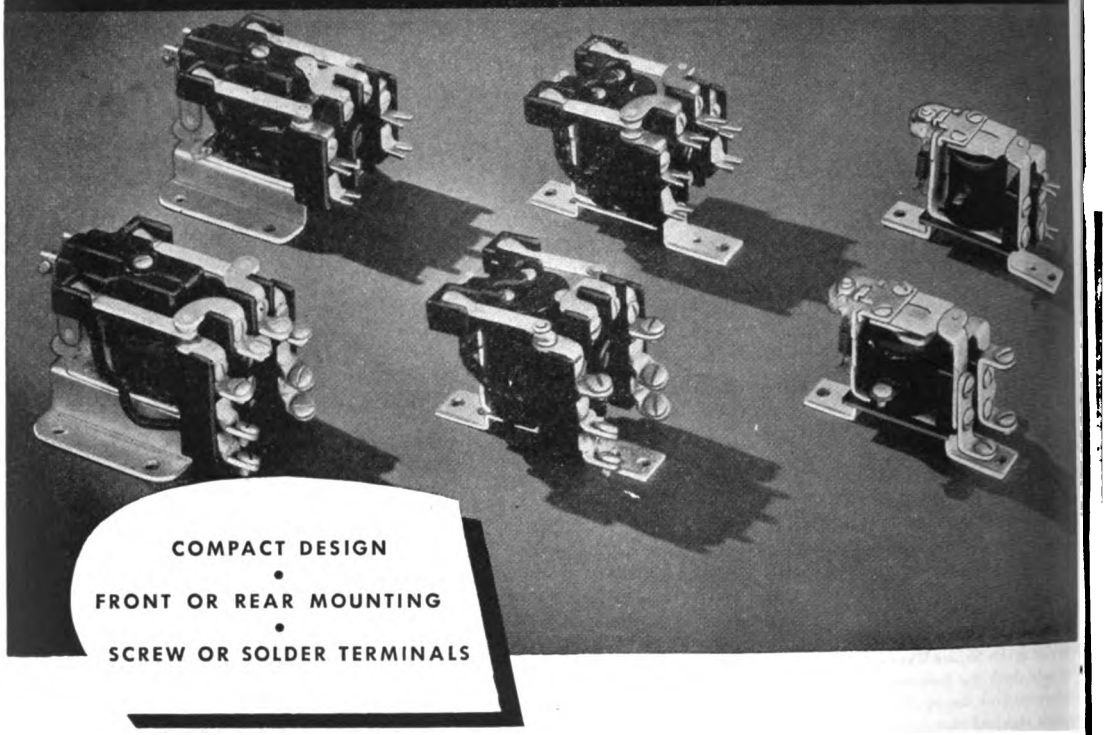

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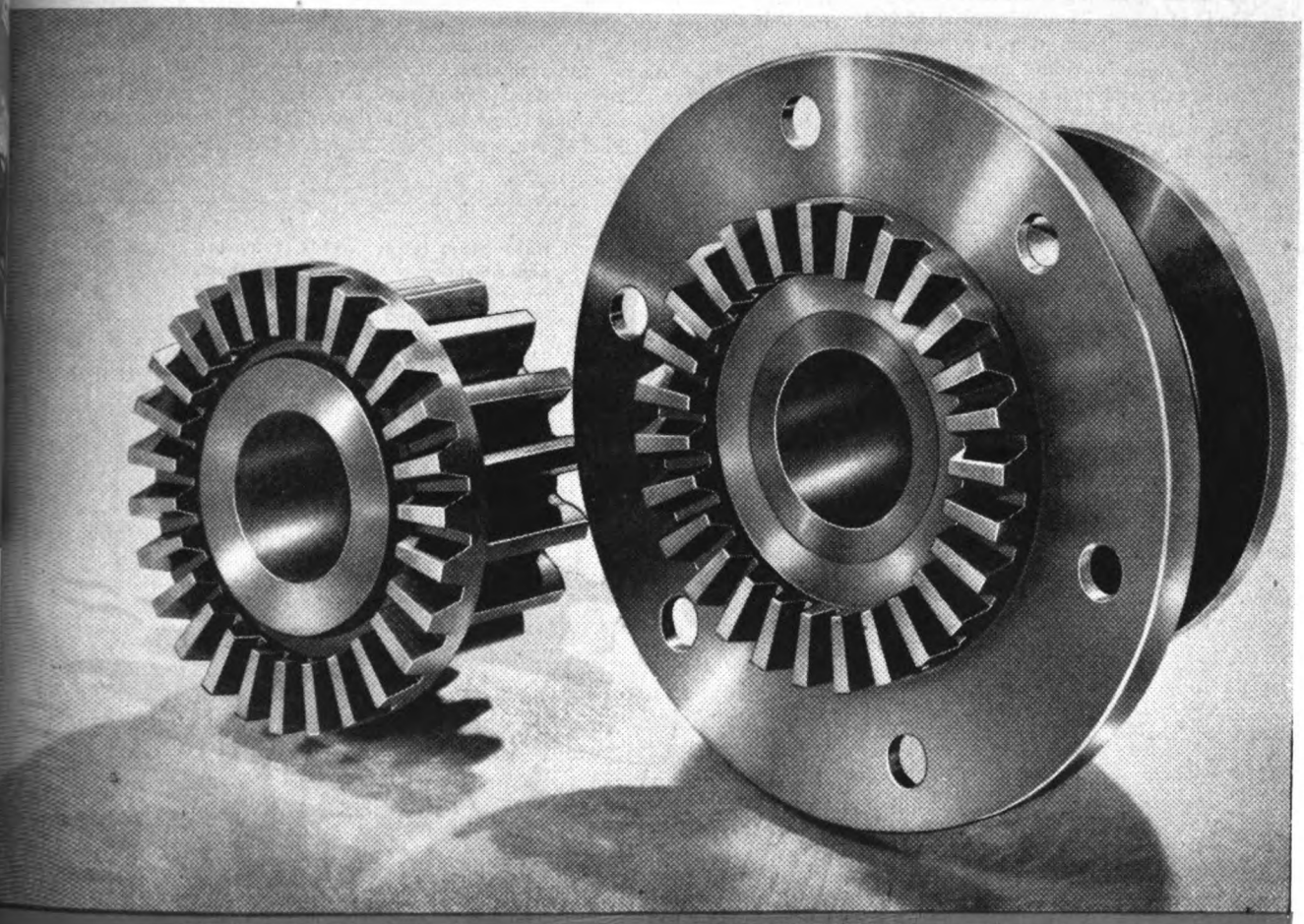

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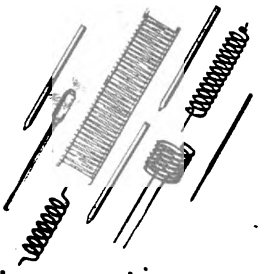

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Callite thoriated tungsten filaments contain the right proportions of tungsten and thoria to give the required electronic emission, plus the strength to withstand severe thermal shock and vibration. Callite's "Kulgrid"* is a stranded composite wire, having an inner core of copper bonded to a nickel sleeve, which does not oxidize nor become brittle at high temperatures. Callite's high purity molybdenum rod is known for its excellent working properties and complete freedom from oxidation.

If you are striving for new highs in tube performance, investigate our specialized abilities and complete facilities for all kinds of metallurgical components. Callite Tungsten Corporation, 544 Thirty-ninth St., Union City, New Jersey. Branch Offices: Chicago, Cleveland.

Callite Tube components

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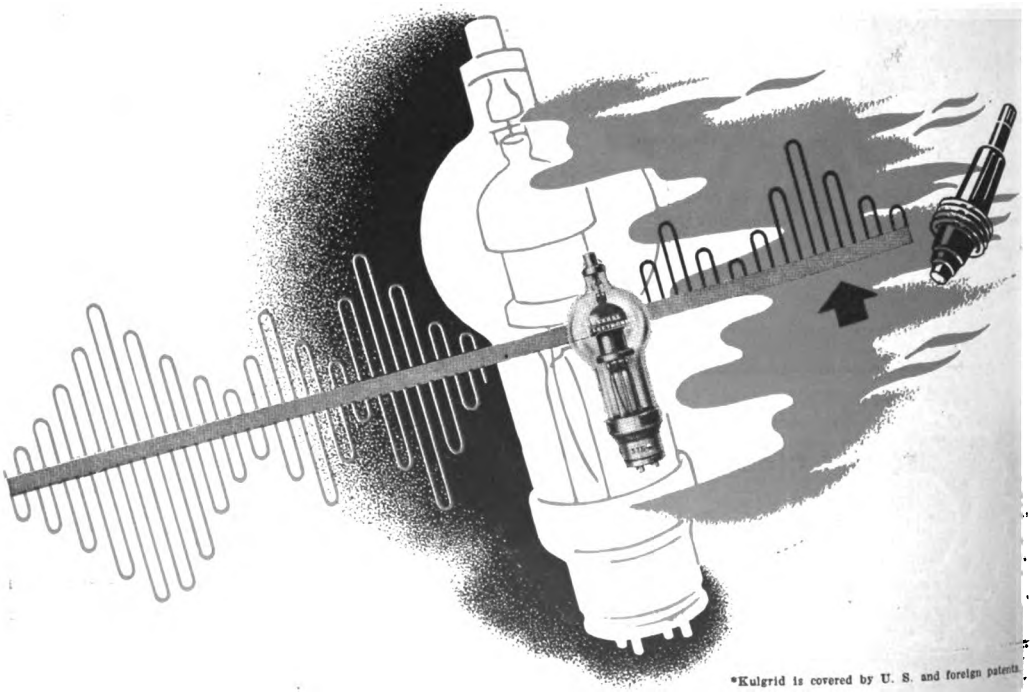

*Kulgrid is covered by U. S. and foreign patents.

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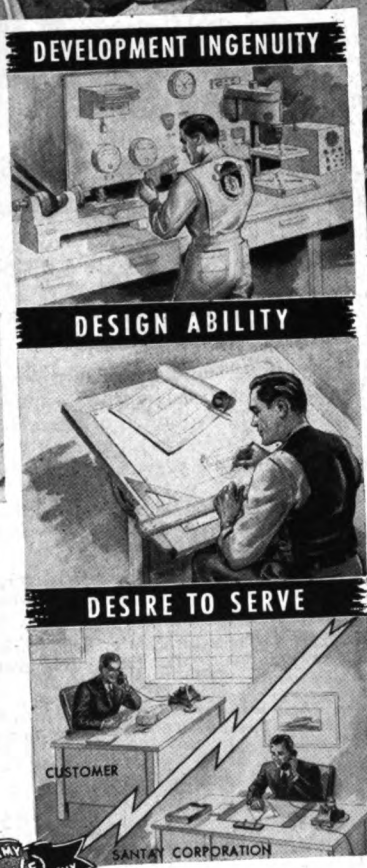

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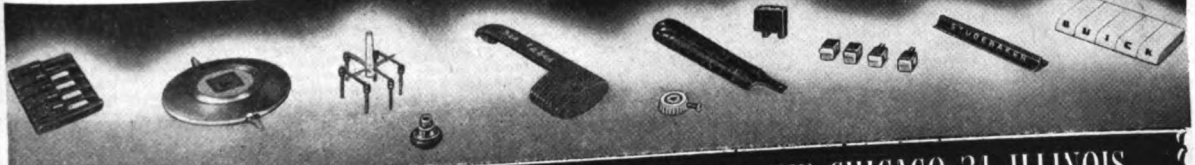

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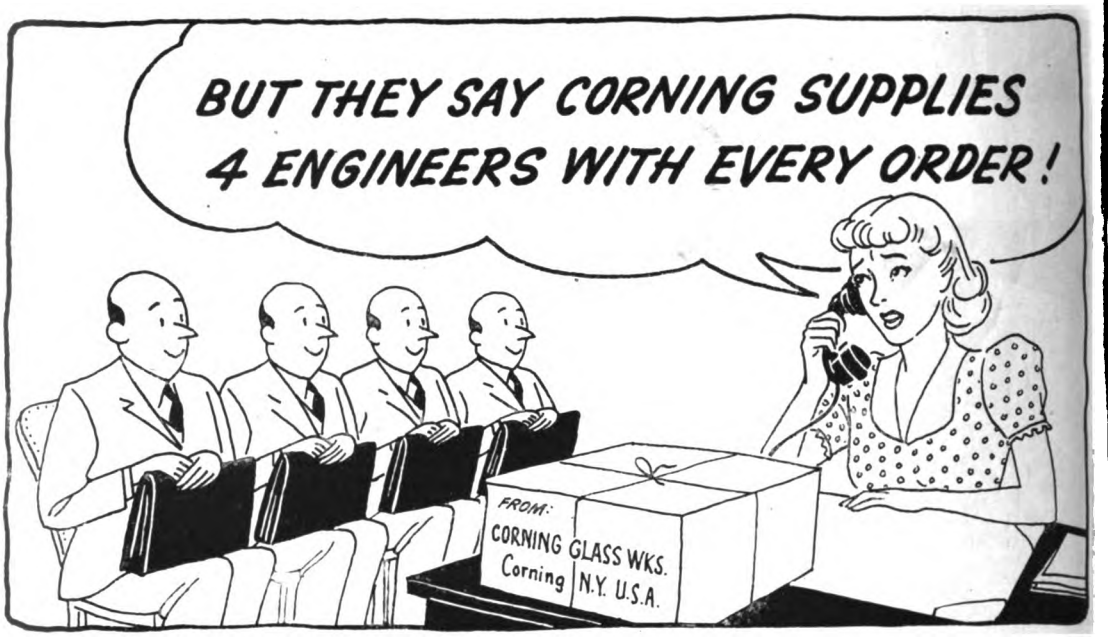

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IT'S quite a job getting a new electronic product into production. Materials, methods and prices buzz around your head like a bunch of bees. But you don't have to solve your problems all alone. For Corning has four special engineering services to help you:

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2. Product Engineers—Technical men who translate Corning Research in Glass into practical applications which may solve your particular headaches.

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4. Technical Service Engineers — These men get you started right. They help your people lick the production bugs.

Of course, Corning Electronic Glassware also means thousands of glass formulae so you can get the right one for your job. It means Corning's unique metallizing process forming a permanent bond between glass and metal. Tubes, bushings, headers, etc., can be soldered in place to form permanent hermetic seals. It means an entire plant at Bradford, Pa., devoted exclusively to the manufacture of electronic specialties quickly, in large quantities. To get the fastest service in solving your pet problem, write, wire or phone Electronic Sales Department, E-12, Technical Products Division, Corning Glass Works, Corning, New York.

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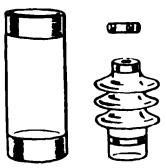
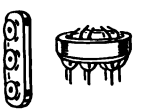


Metallized Bushings. Tubes in 10 standard sizes, ⅛" x 15/32" to 1" x 4½" in mass production for immediate shipment.



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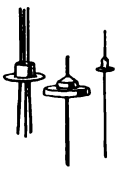

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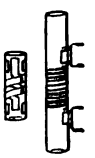

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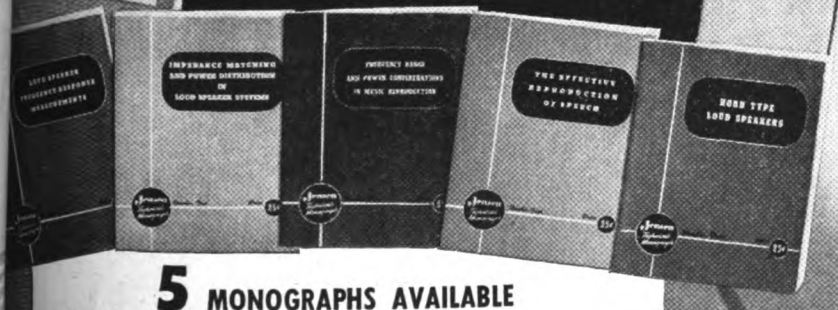

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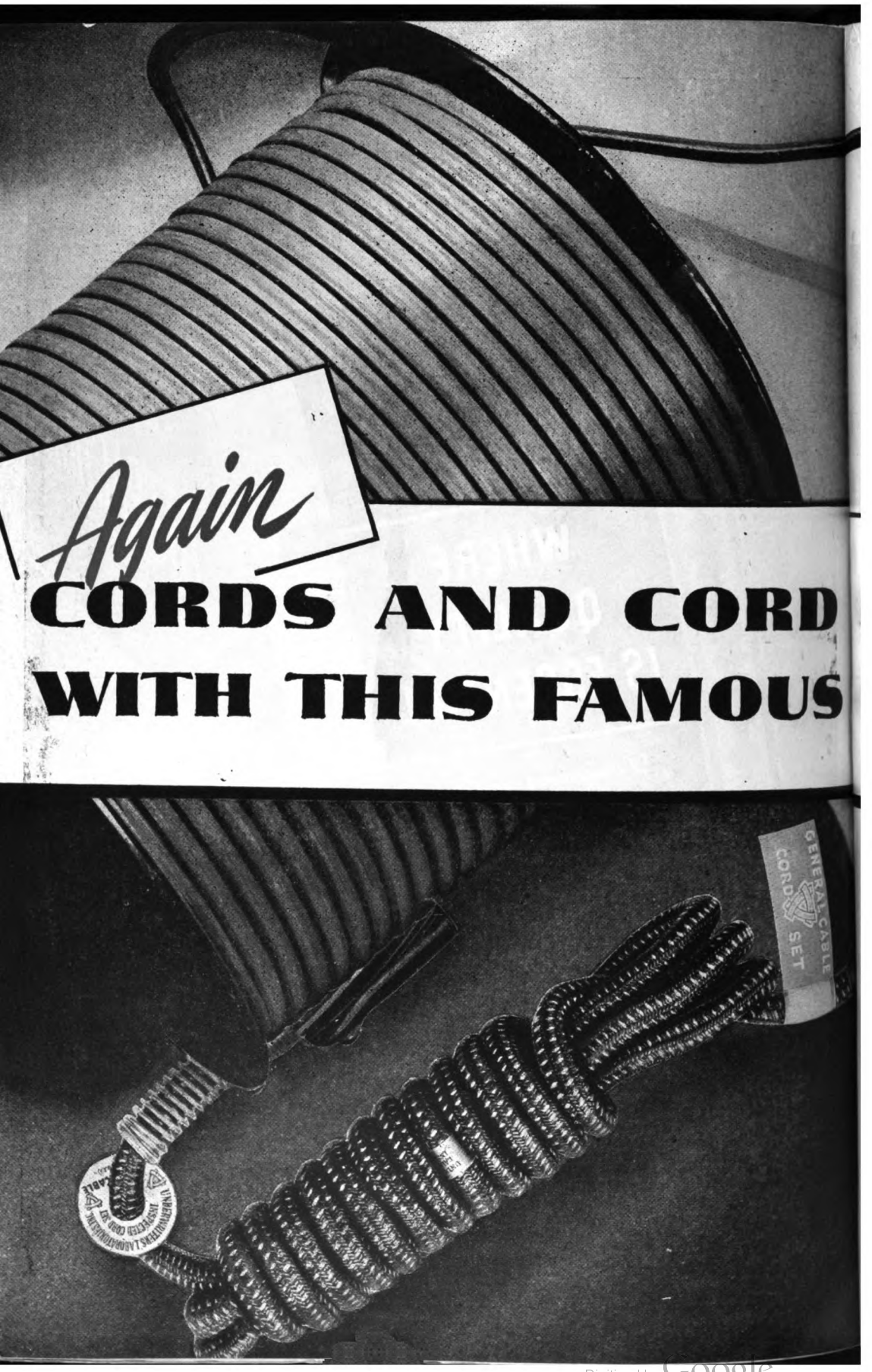

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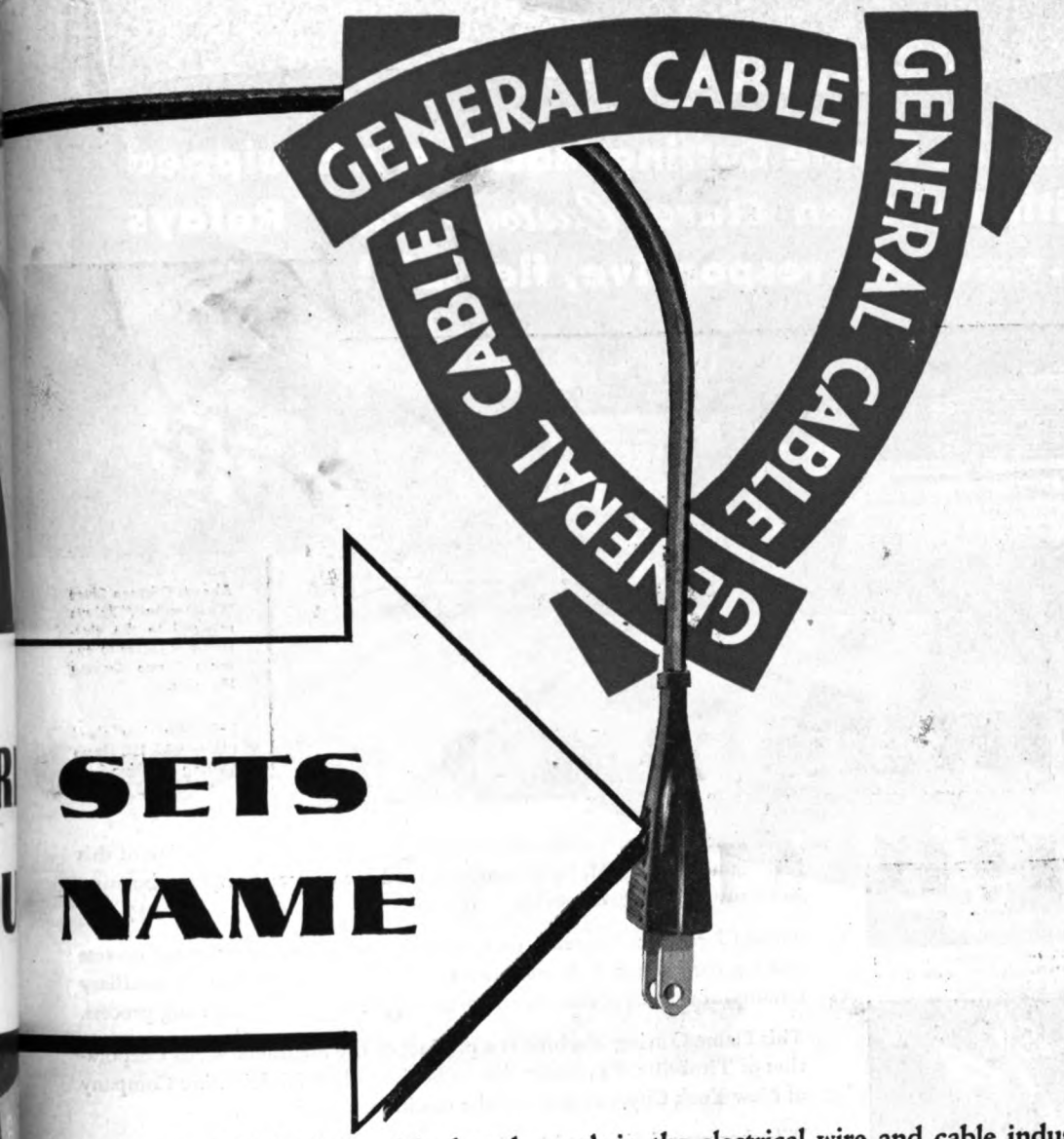

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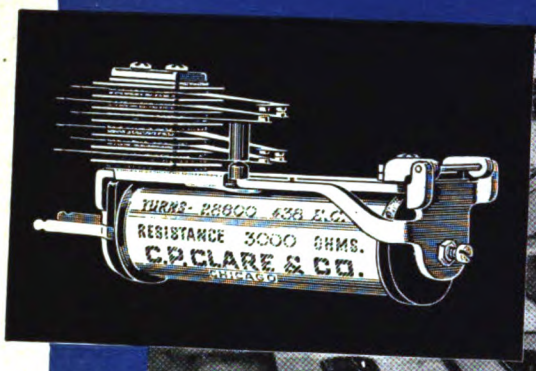
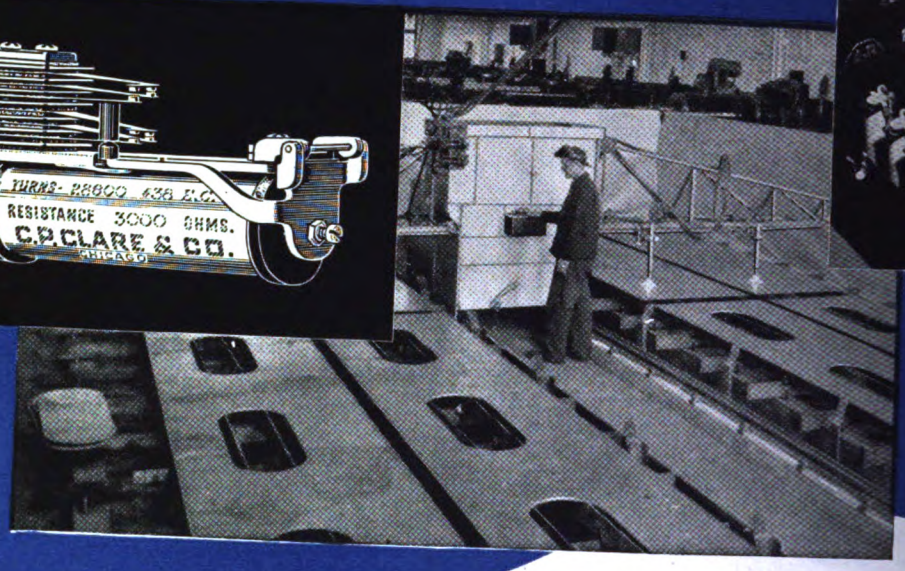
This ISC Flame Cutting Machine is Equipped with Thirteen Clare "*Custom-Built*" Relays ...accurate, responsive, flexible!

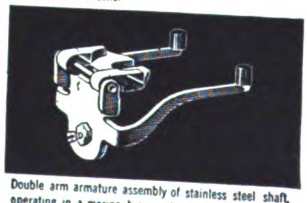




Contacts are welded to nickel silver springs by special process. May be of precious metals or alloys in 12 different standard, or special, types and sizes.

Spring bushing insulators are made of Bakelite rod under patented process. Resist vibration and withstand heavy duty service.

High voltage spring pile-up insulators of special heat-treated Bakelite. Has minimum cold flow properties, low moisture absorption content, and permits punching without cracks or checks.



Double arm armature assembly of stainless steel shaft, operating in a marine brass yoke. Heelpiece core and armature assembly of magnetic metal.

• Thirteen Clare "Custom-Built" Relays are used in the operation of this ISC Flame Cutting Machine which is used for oxygen-acetylene burning in shipyards and steel works.

These Clare Relays operate on electronic impulses to start, stop, reverse and jog the 3-phase A. C. motors which connect and disconnect auxiliary circuits for various automatic and manual operations in the cutting process.

This Flame Cutting Machine is a product of the Struthers Wells Corporation of Titusville, Pa., under license of the Industrial Scientific Company of New York City, designers of the machine.

Whether your design problem involves sequence control of machine tools, electric eye controls, counting equipment, alarm systems, radio, radar or other electronic controls, Clare can "custom-build" a relay to meet your exact requirements.

Let Clare engineers know your specific relay problems. Let them show you the wide range of contact arrangements, spring assemblies and special contacts that can be "custom-built" into a Clare Relay to meet your specifications.

Write for the Clare catalog and data book today. It will pay you to know all about Clare "Custom-Built" Relays and what they can mean to you in the reduction of relay costs. Address: C. P. Clare & Co., 4719 West Sunnyside Avenue, Chicago 30, Illinois. Sales engineers in all principal cities. Cable address: CLARELAY.

CLARE RELAYS

"Custom-Built" Multi-Contact Relays for Electrical, Electronic and Industrial Use

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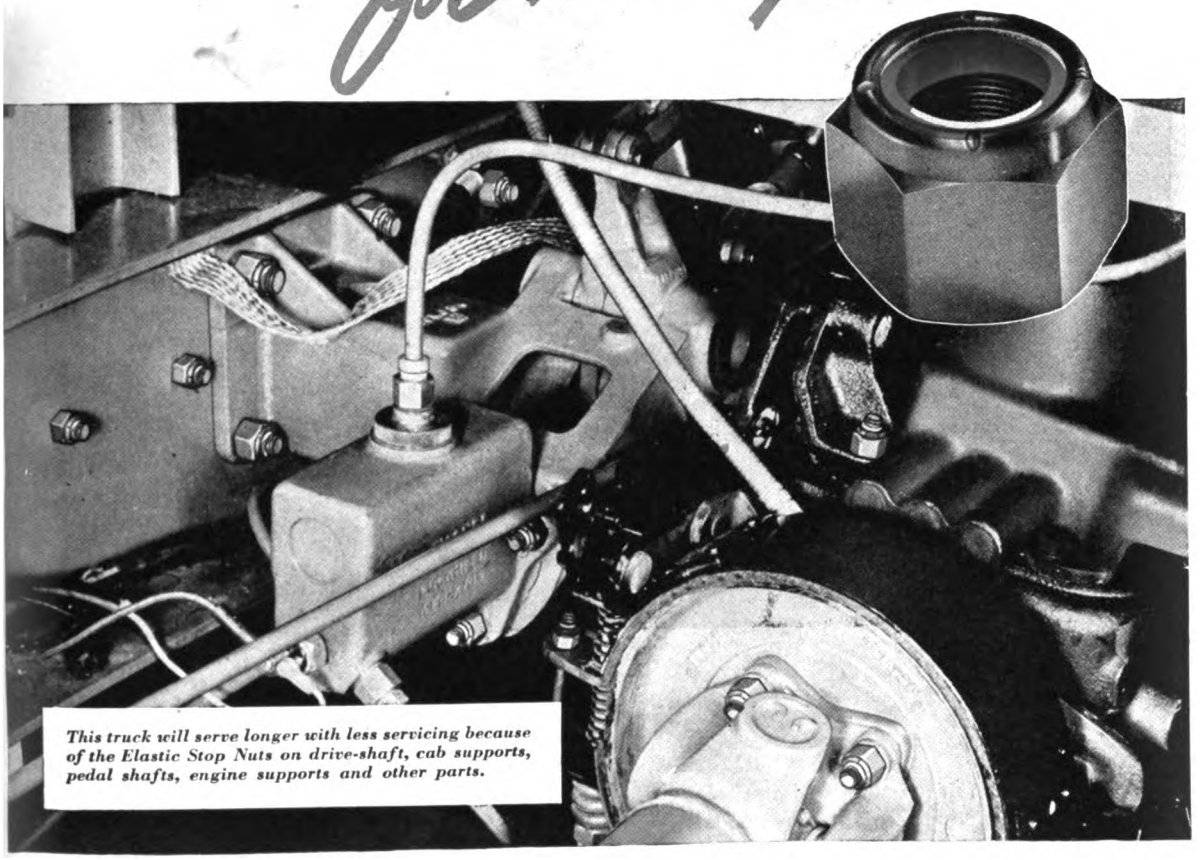
HERE'S THE HEADLINER

for holding power



This truck will serve longer with less servicing because of the Elastic Stop Nuts on drive-shaft, cab supports, pedal shafts, engine supports and other parts.

THE ELASTIC *Self-Locking* STOP NUT USES ITS HEAD

Making headline news among sales executives the country over is the Elastic Self-Locking Stop Nut, the nut with the famous red collar.

For sales executives are quick to recognize top-merit features that add sales appeal and widen public acceptance. The nut with the red collar, the hold-fast nut, adds value to trucks, passenger cars, vacuum cleaners, lawn mowers, radios and a host of other things because it assures longer, trouble-free service.

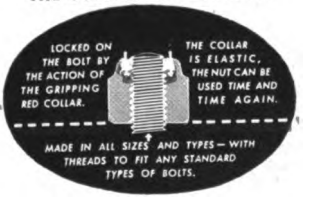
In industry, in the home, in office, factory and on the farm, red-collar nuts are finding thousands of new applications—holding fast wherever vibration, shock, impact or other loosening influences could cause trouble of any sort, from individual annoyance to multiple fatalities. They simply won't come loose. Not until you take a wrench and deliberately remove them. Then they turn off readily, for the metal threads are sealed-free of rust.

Tough and resilient, the red collar is unthreaded and gauged slightly smaller than the bolt. Bolt threads force their way in, do not cut, and a friction grip is set up. This overcomes the effects of vibration and other loosening forces—and because the collar retains its gripping power, the nuts may be used over and over again.

An application engineer will be glad to call on you and discuss ways Elastic Self-Locking Stop Nuts can help you.

LOOK FOR THE RED COLLAR

THE SYMBOL OF SECURITY



ESNA

TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA

Union, New Jersey

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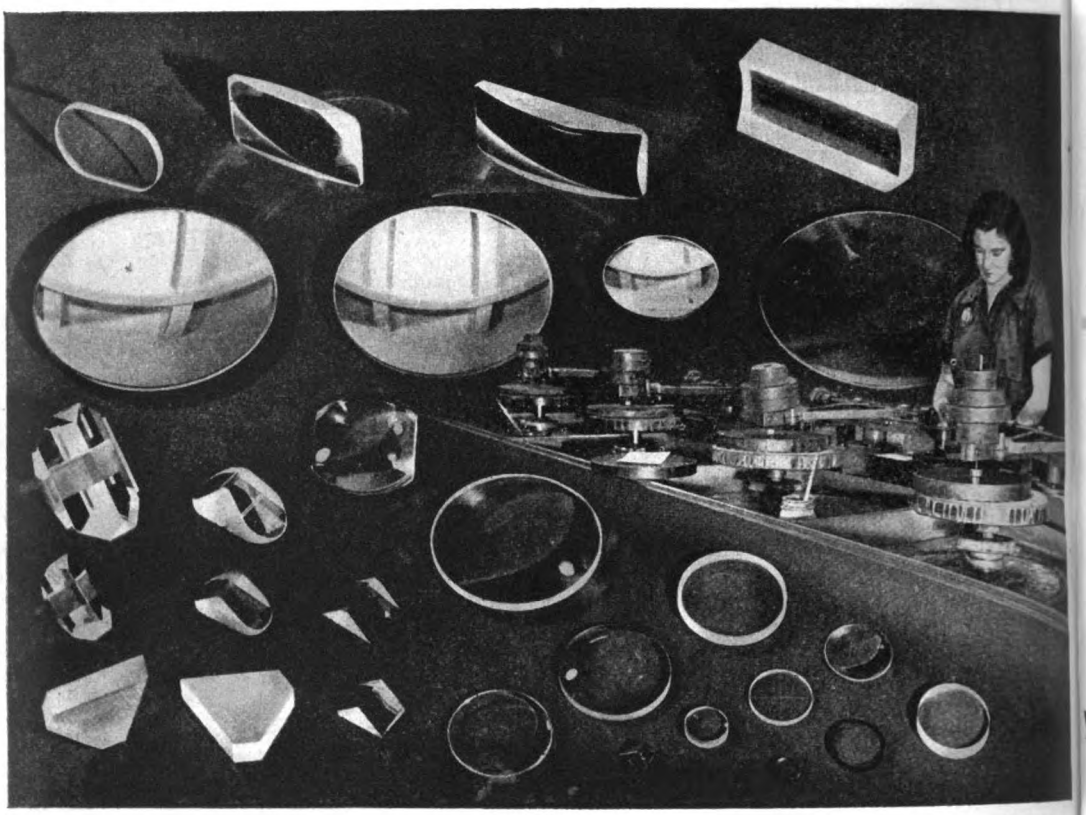

Optics to order—by AMERICAN methods

Every component in this picture is as precise as a top-flight craftsman could have made it by hand. But each and every one of them was produced in large quantities. Furthermore, they were all made to order for exacting customers to meet rigid specifications.

Modern machines, of our own improved design, operated and controlled by highly-skilled American workers, enable us to produce precision optics at a high production level. The result is fine quality at a saving.

Our compact group of trained technicians is ready to go to work for a few additional manufacturers. But, as reconversion progresses, our plant becomes increasingly busy. Those who need optics should readily see the wisdom of making their requirements known to us at an early date so that we can give them the prompt service demanded by these times.

A new booklet, "Precision Optics by American Methods," tells how our company has developed optical manufacturing techniques, why we continue to concentrate all our efforts on the production of precision optics for others, and how we can be of exceptional service to those who need optical components. We shall be pleased to send you a copy of this new booklet on request.

for precision OPTICS *come to*

AMERICAN LENS COMPANY, INC.

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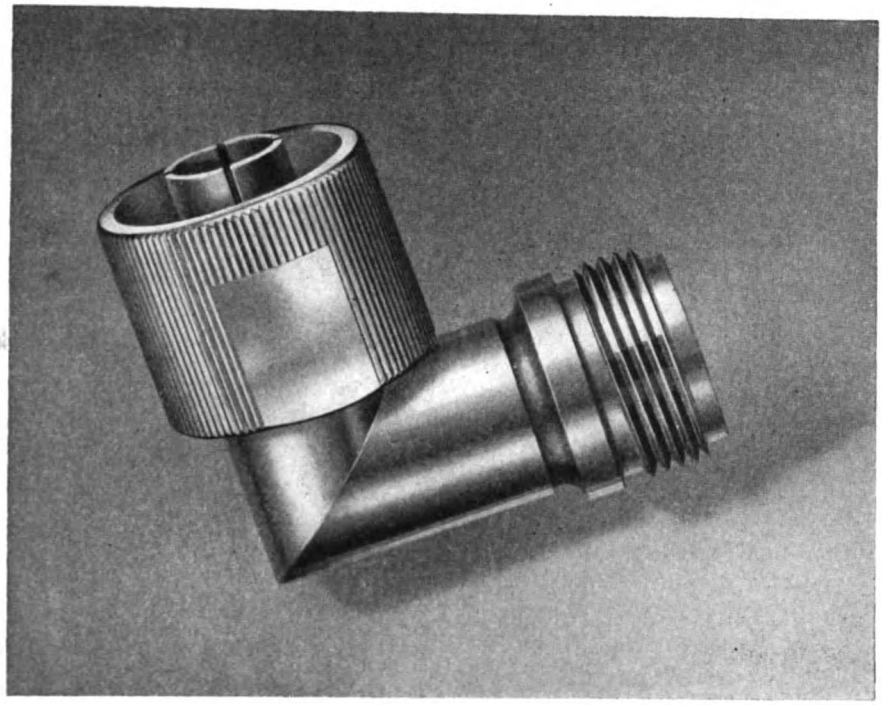
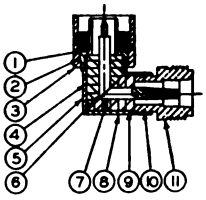
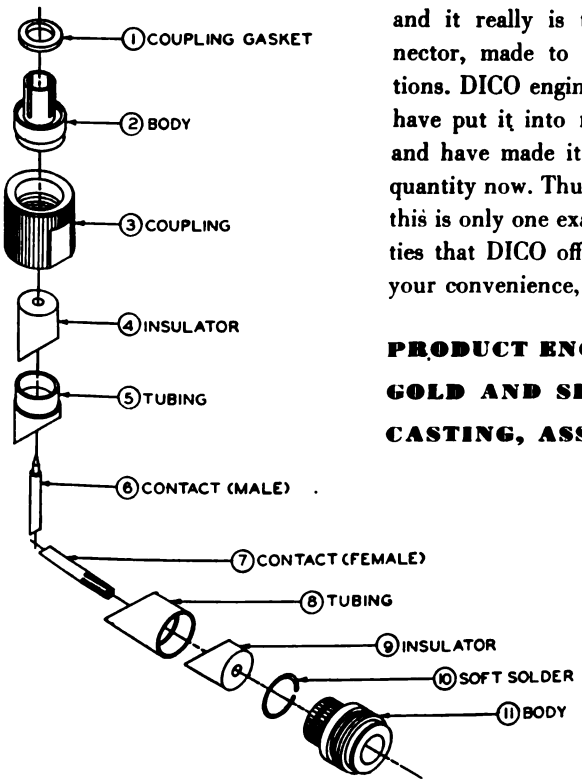


YES, IT'S HERE FOR YOU—

SECTION THROUGH CONNECTOR





and it really is the UG-27/U angle connector, made to the latest JAN specifications. DICO engineering and technical skill have put it into mass production for you and have made it available for delivery in quantity now. Thus another supposed impossibility has become possible; and this is only one example of what can be done through the unsurpassed facilities that DICO offers you. Our representative will call for consultation, at your convenience, without obligation.

PRODUCT ENGINEERING, DESIGNING, DEVELOPMENT; GOLD AND SILVER PLATING; SOLDERING, WELDING, CASTING, ASSEMBLING, FINISHING.

DICO

DIAMOND INSTRUMENT CO.

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Quiet

Efficient—reliable—above all, *QUIET*—
that's the Ballentine Phonograph Drive.
Basic refinements in design, *precision dynamic balance*, the most advanced manufacturing technique and equipment make the Ballentine Phonograph Motor unequalled for low background noise or rumble.
Send for descriptive bulletin.

RUSSELL ELECTRIC COMPANY
364 WEST HURON ST., CHICAGO 10, ILL.
Manufacturers of
BALLENTINE PHONOGRAPH DRIVE

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Light? We call it "LIGHT FANTASTIC

. . . a transformer headed for 65,000 feet "altitude" . . . at 350 degrees temperature!

And to top it off, it had to be "lighter than anything on the market," *they said. What, we asked, was it for? They couldn't tell us, and we don't know to this day, but we do know it was badly needed.

"It has to operate not only on a 60-cycle current at ground level, but from 400 to 2600-cycle current, and what's more, at a simulated altitude of 65,000 feet."

Thermador built this special transformer equipment. It passed the above mentioned requirements. That wasn't enough. They gave it another test, in which they changed the temperature from ambient (the temperature of a fairly warm room) to 350—in two hours. It passed that test, too. This is all we know of one of the most mysterious jobs we ever did, in the not-mysterious method in wh built all of our tansformers.

*For reasons of military security names cannot be given.

THERMADOR TRANSFORMERS

DEFEAT HEAT • COLD • HUMIDITY

THERMADOR ELECTRICAL MANUFACTURI

5119 SOUTH RIVERSIDE • LOS ANGELES 22, CA

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more efficient ...in miniature

ACTUAL SIZE

The cast iron pump was modern two or three generations ago. It was a big improvement over the old oaken bucket. But today we use a comparatively small faucet that supplies water at a twist of the wrist. It is another milestone on the road to greater efficiency in miniature.

This same tendency is evident in the development of the Electronic Tube. The Tung-Sol Miniature is the result of the trend to smaller component parts. It is used to great advantage in reducing the over-all size of equipment. But more important, Tung-Sol Miniatures do a more efficient job than the old style tube; especially in high frequency circuits. They have a low capacity and high mutual conductance. Shorter leads give them low inductance. Smaller elements weigh less, making Miniatures more rigid. This helps to eliminate distortion from vibration.

When planning new electronic devices or when improving old ones, discuss circuits and tube selection with Tung-Sol engineers. Their services are at your disposal. Such conferences are held in strictest confidence.

TUNG-SOL

vibration-tested

ELECTRONIC TUBES

TUNG-SOL LAMP WORKS INC., NEWARK 4, NEW JERSEY

Also Manufacturers of Miniature Incandescent Lamps, All-Glass Sealed Beam Headlight Lamps and Current Intermittors

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A CLASS "C" INSULATION—
INORGANIC CERAMIC—
APPROXIMATELY 1/4 MIL THICK—
PERMITS CONTINUOUS
OPERATION AT 200° C.

THE WIRE INSULATION ...that will not burn!

ARMY E NAVY

Sprague CEROC 200 is an inorganic, non-inflammable ceramic wire coating supplied in a preferred thickness of only ¼ mil and holding vast opportunities for smaller size and lighter weight with greatly increased power for a wide variety of electrical equipment. By using it, midget size windings can be made to do man-size jobs—with safe, conservative operation up to 200°C. if necessary. Space factor is higher than that of any other type of wire insulation and, despite its ceramic nature, CEROC 200 can readily be wound to meet most requirements.

MIDGET-SIZE WINDINGS
DO MAN-SIZE JOBS!

Write for copy of CEROC 200 Bulletin 505

SPRAGUE ELECTRIC CO., NORTH ADAMS, MASS.

SPRAGUE *Ceroc200

(*Trademark Reg. U. S. Patent Office)

Pioneered and Produced by the Makers of SPRAGUE CAPACITORS and *KOOLOHM RESISTORS

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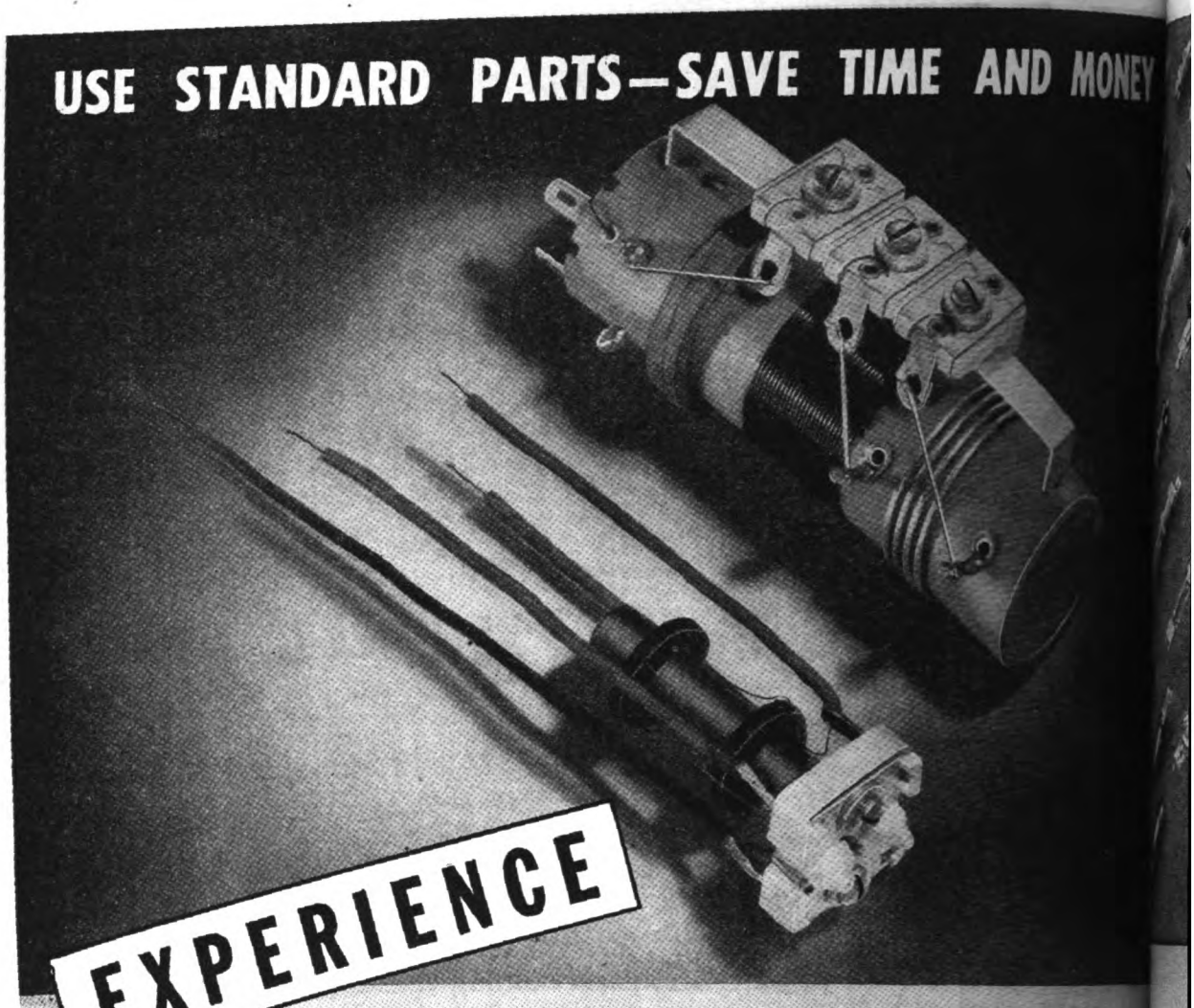
USE STANDARD PARTS—SAVE TIME AND MONEY



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For many years
Automatic has manufactured
Coils and Trimmers for manufacturers.

Our mass-production methods
will save you money and headaches.

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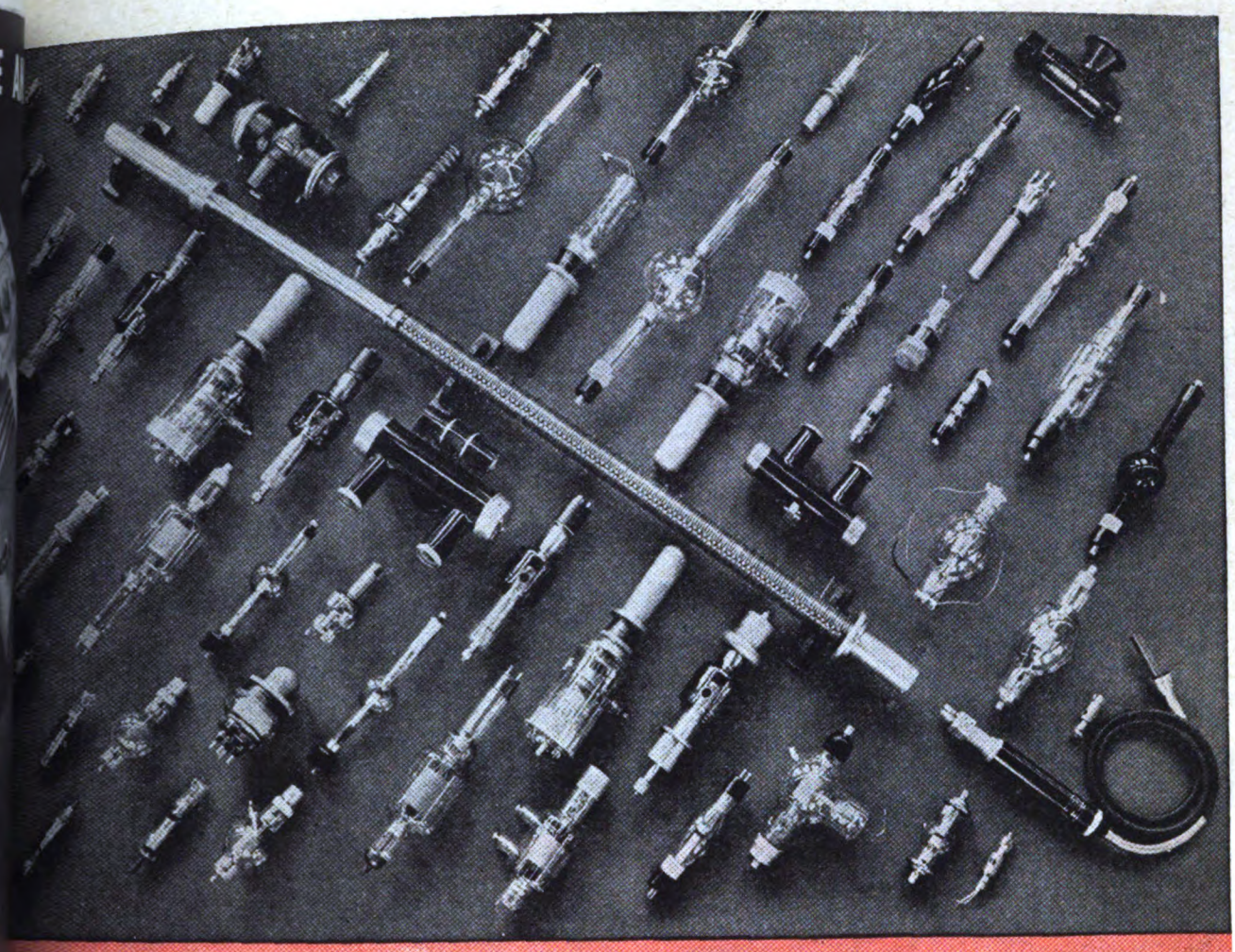

GROUPED about the widely acclaimed Two-million-Volt Precision X-ray Tube are other Machlett tubes for medical, industrial and radio purposes. In each of these tubes are incorporated the inherent skills employed by Machlett in the development of this unique tube. They are your assurance of long life, ruggedness and dependability in whatever field they are used. Machlett Laboratories, Inc., Springdale, Connecticut.

MACHLETT

APPLIES TO RADIO AND INDUSTRIAL USES
ITS 18 YEARS OF ELECTRON-TUBE EXPERIENCE

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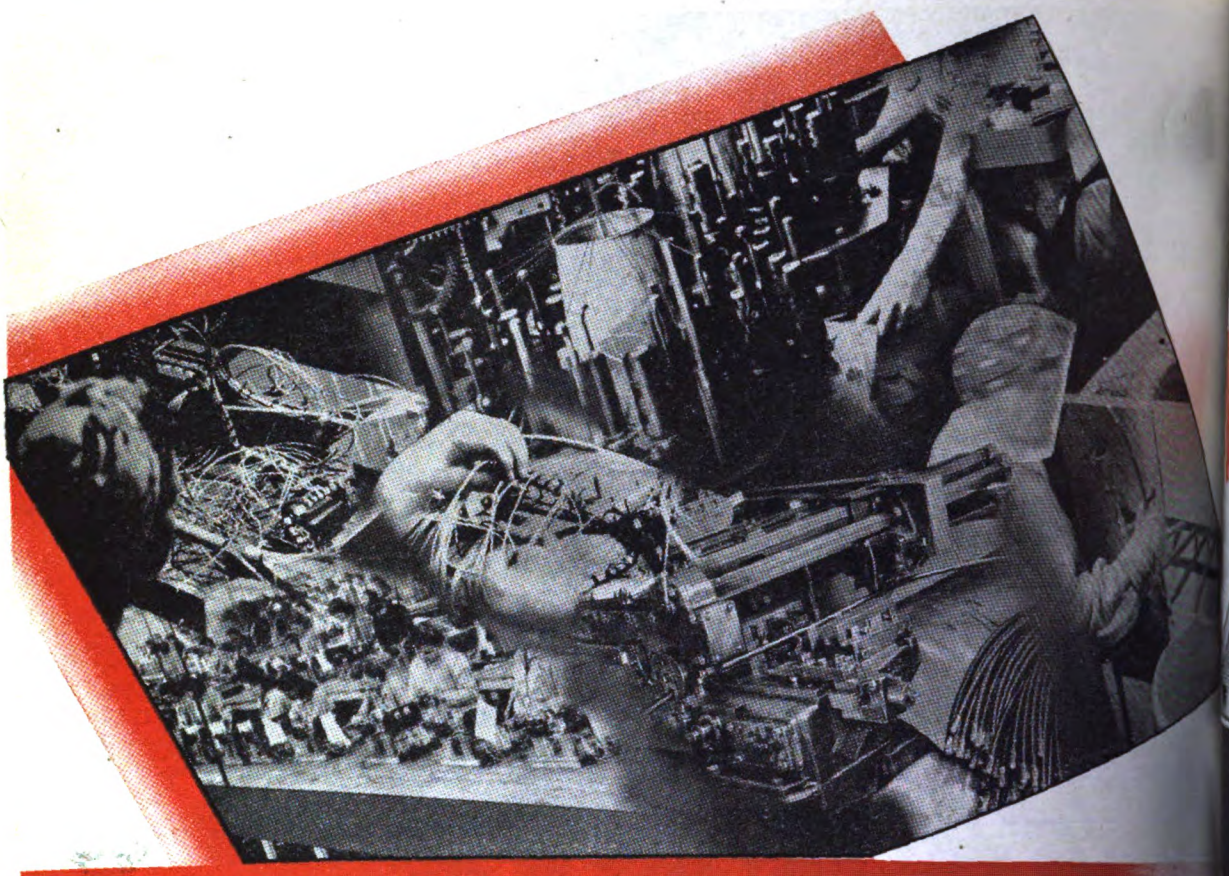

ENGINEERED CABLE ASSEMBLIES at a fixed production cost to you

If your product requires WIRING HARNESSES...CABLE ASSEMBLIES...BONDING JUMPERS... CABLE or TERMINALS—you'll find that a lower cost of manufacturing, at a fixed production cost to you, is one of many advantages Whitaker offers you.

In turning the production of your wiring requirements over to us you are assured quality merchandise made to the most exacting specifications. When your men install the completed assemblies they will find every lead and every terminal properly positioned for the right connection. The economies gained will be big factors in enabling you to lower your cost of manufacturing.

In addition to an engineered wiring service, Whitaker also offers a quality line of standard cable products . . . Write for latest catalog, and complete information.

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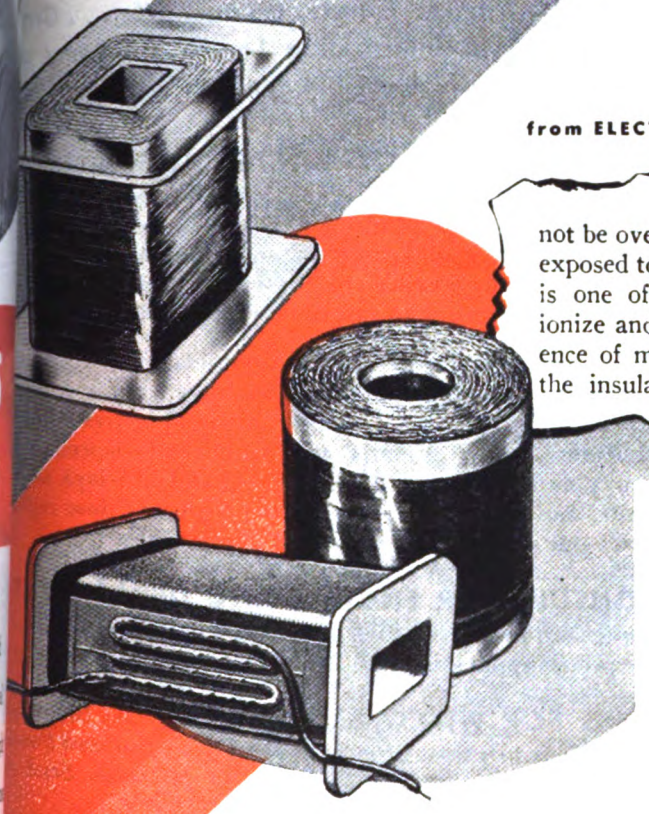
Don't let INSULATION be the WEAK LINK in your product



Read this paragraph

from ELECTRICAL MANUFACTURING, AUGUST, 1945, page 212

However, cellulose acetate insulation cannot be overlooked, particularly for low temperature coils exposed to severe humidity conditions. Cellulose acetate is one of the few insulating materials that will not ionize and atttack the copper magnet wire in the presence of moisture so that it plays an important role in the insulation of extremely small magnet wire coils.

ELECTRICAL PARTS and products from the smallest size to the largest, can be effectively protected against electro-chemical corrosion by use of Lumarith CA (cellulose acetate) insulation.

Lumarith CA is available in these forms:
films, foils and sheets
extruded rods and tubes
molding materials for injection and extrusion

Lumarith CA has these additional advantages:
high dielectric strength
resistance to salt water
resistance to mildew and fungus
resistance to transformer oils
high arc resistance

Use Lumarith films and foils for interlayer insulation, inter-phase insulation, slot insulation, coil wraps and covers, laminates, wire insulation. Special A78 mat finish (one side) can be supplied.

Use Lumarith sheets, rods, tubes and molding materials for coil forms, separators, bus bar insulation, radio and instrument housings, fluorescent lighting parts, formed insulators, bezels, coil supports, nameplates, switch gear windows.

Lumarith CA is a product of Celanese research. Write for latest Celanese electrical booklet. Celanese Plastics Corporation, a *division of Celanese Corporation of America*, 180 Madison Avenue, New York 16, N. Y.

LUMARITH* CA

A CELANESE* PLASTIC

*Reg. U. S. Pat. Off.

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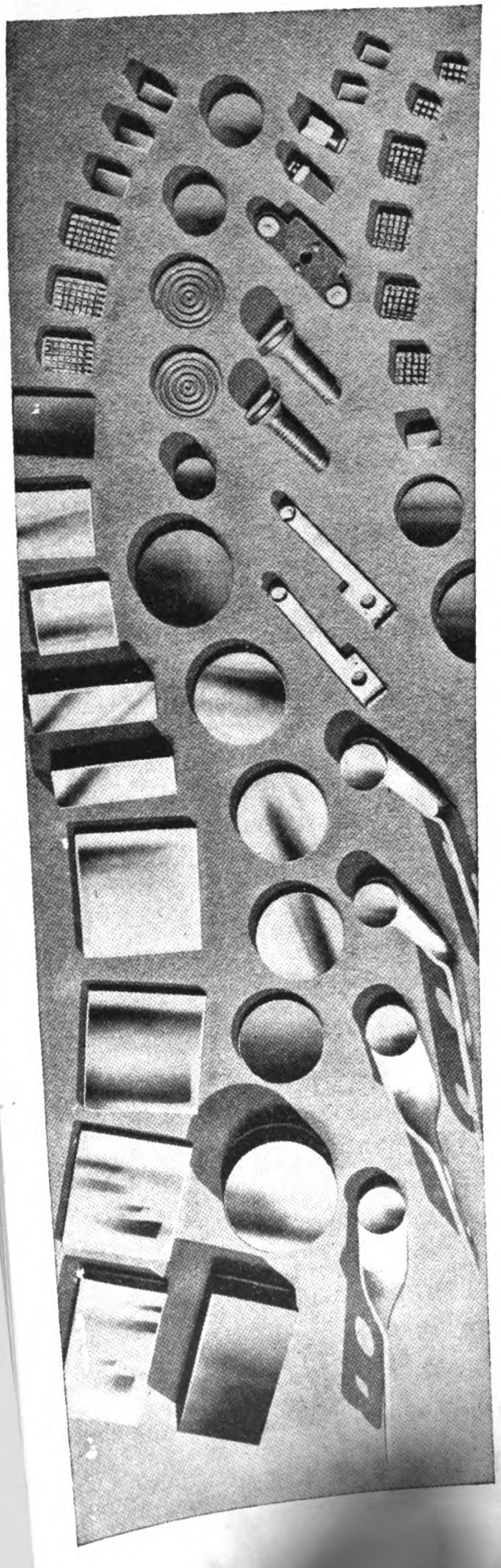
ANOTHER WILCO DEVELOPMENT



Wilcoloy

(SINTERED POWDER METAL CONTACTS)

WILCOLOY *offers* Longer Contact Life . . . Greater Resistance to Interrupting Loads, *and many other advantages for high current applications.*

PROPERTIES AND CHARACTERISTICS—WILCOLOY Silver Tungsten, Copper Tungsten, Silver Graphite, Silver Molybdenum and other WILCOLOY contact materials assure a degree of longevity, and thermal and electrical properties not possible to materials previously used in applications subject to severe current interruptions.

These Sintered Powder Metal Contacts offer a choice of properties including ductility, hardness, density, freedom from sticking, low metal transfer, high conductivity and arc-resistance. They perform uniformly and dependably in heavy duty circuit breakers, both air and oil relays, aircraft units, motor brushes, commutator segments, fuse replacement units and other specialized applications.

CONSULT OUR ENGINEERING DEPARTMENT—Write our Engineering Department for help in developing the proper application of WILCO materials to your products.

SEND FOR WILCO BLUE BOOK—The Blue Book contains descriptions of most WILCOLOY Sintered Powder Metal Contacts and other WILCO products. Send for FREE copy today.

WILCO PRODUCTS INCLUDE:

CONTACTS—
Silver
Platinum
Tungsten
Alloys
Sintered Powder Metal

THERMOSTATIC BIMETAL—
All Temperature ranges, deflection rates and electrical resistivities.

PRECIOUS METAL COLLECTOR RINGS—
For rotating controls

SILVER CLAD STEEL—

JACKETED WIRE—
Silver on Steel, Copper, Invar or other combinations requested.

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SPECIAL MATERIALS

THE H. A. WILSON COMPANY
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SPECIALISTS FOR 30 YEARS IN THE MANUFACTURE OF THERMOMETALS ELECTRICAL CONTACTS • PRECIOUS METAL BIMETALLIC PRODUCTS

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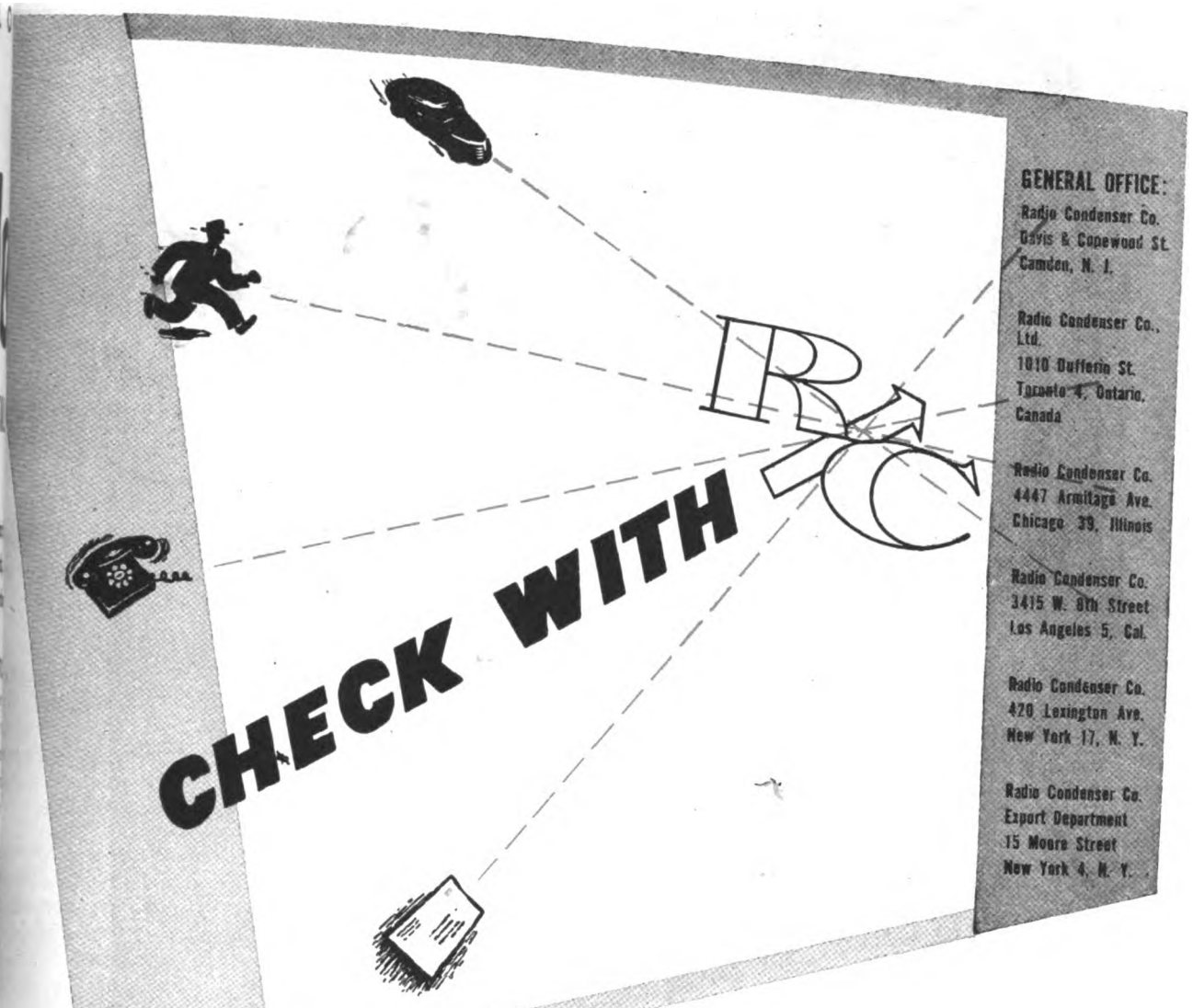
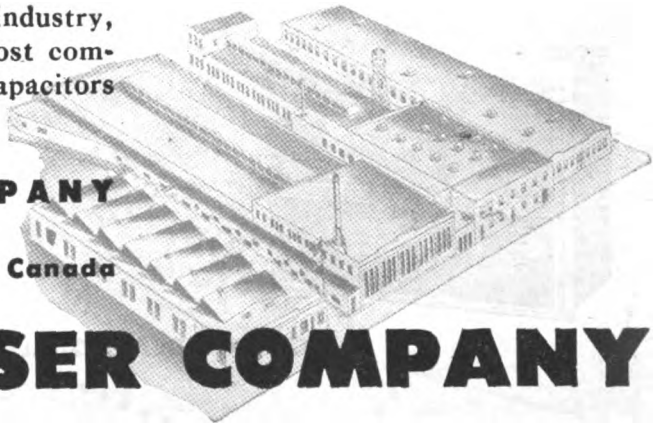


. . . when Variable Capacitor KNOW-HOW makes a difference!

We design and build ONLY variable capacitors and mechanical tuning devices.

This factor, more than any other, has contributed to the high degree of R/C specialized knowledge in the field of variable capacitor design and manufacture.

With a history of almost a quarter of a century as suppliers to the set manufacturing industry, Radio Condenser Company offers the most complete engineering background in variable capacitors and mechanical tuning devices.



RADIO CONDENSER COMPANY
CAMDEN, N. J.
RADIO CONDENSER CO., Ltd., Toronto, Canada

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SUPPLIERS TO SET MANUFACTURERS ONLY

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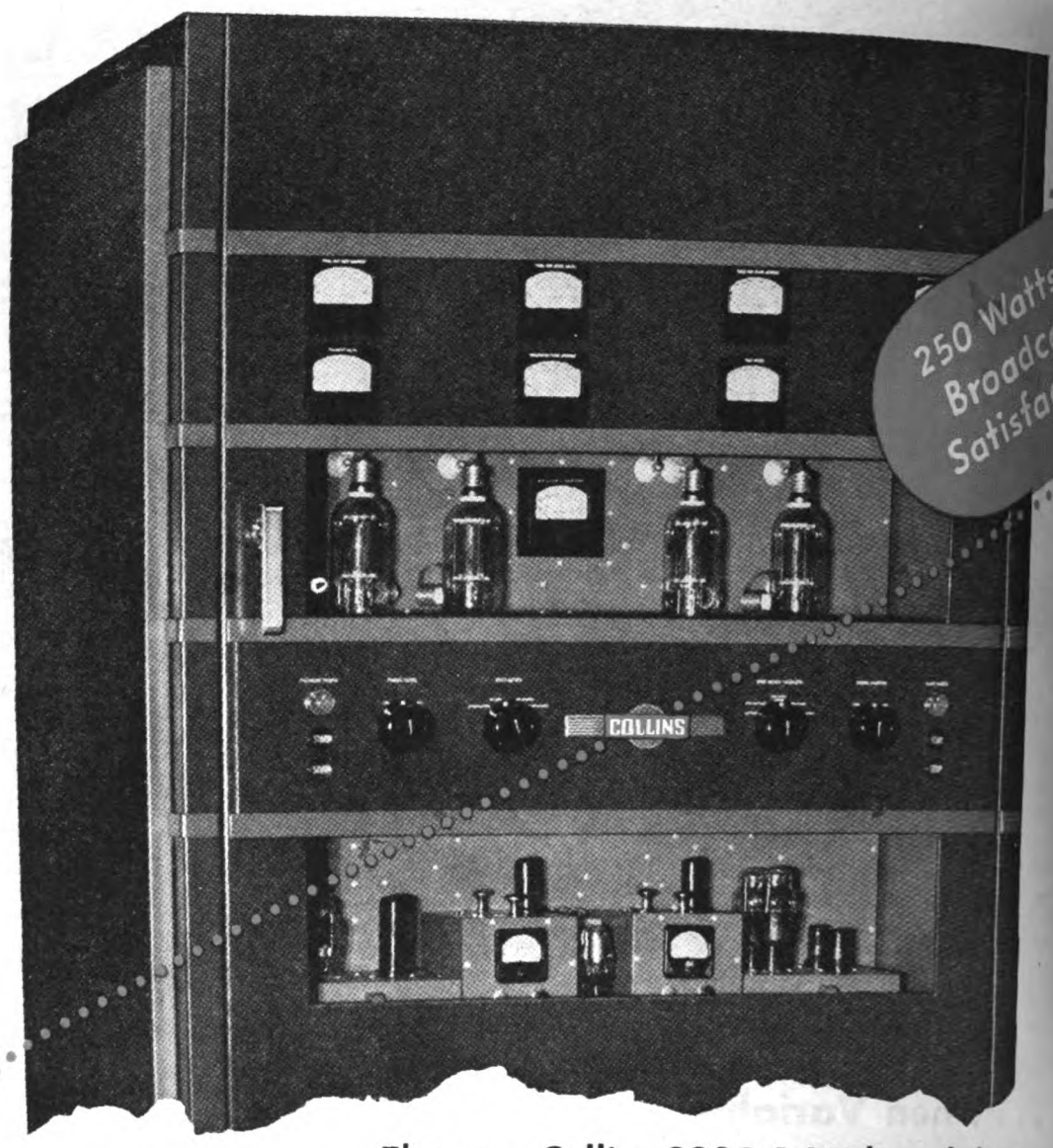

Collins 12Z Remote Amplifier

A high quality four channel remote amplifier, a.c.-d. c. powered. The d. c. source consists of self-contained batteries which take the load automatically in case of a.c. line failure. Gain, approximately 95 db. Frequency response, 30-12,000 c.p.s. ± 1 db. Power output, 50 milliwatts. Weight, with batteries and carrying case, 32 pounds.

The new Collins 300G-1 AM broadcast transmitter is an **operator's ideal.**

Its components are the finest available, with very high safety factors, *and all are completely and immediately accessible.* Replacements, if necessary, are just a quick, simple one-man job!

Circuit design, physical arrangement, and workmanship throughout, meet the superior standards which station engineers have come to expect of Collins engineering.

The nominal power output of the 300G-1, 250 watts, can be reduced to 100 watts by means of a switch on the control panel. The response is flat within ± 1.0 db from 30 to 10,000 cycles. Distortion is less than 3% up to 100% modulation.

Tell us about your plans. We will be glad to study them with you and make recommendations covering requirements for your entire station, AM or FM, and of any power. Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y. In Canada, Collins equipment is sold by Collins-Fisher Limited, Montreal.

FOR BROADCAST QUALITY, IT'S . . .

COLLINS

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Available now!

RADACOR IRON CORES

precision—

produced!

Magnetic Iron Cores, subjected to rigorous tests and designed for use at all frequencies including television and FM, are now available. Our engineering staff will be glad to assist you in determining which of these components can best satisfy your requirements.

Radacor Iron Cores used in these Meissner I. F. transformers permit higher "Q" with a resultant increase in selectivity and gain.

ELECTRONIC & MECHANICAL POWDER METALLURGY

MICRO-FERROCART PRODUCTS DIVISION

MAGUIRE INDUSTRIES, INC.

STAMFORD, CONN.

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MORE POWER OUTPUT BUT LESS BATTERY DRAIN WITH HYTRON INSTANT-HEATING BEAM TETRODES

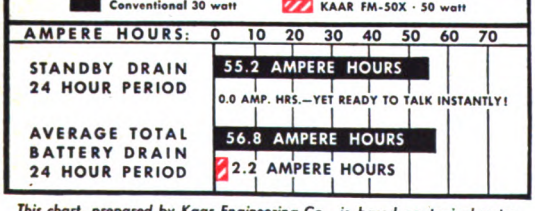
ZERO STAND-BY CURRENT Thoriated tungsten filaments of the Hytron 2E25, HY69, and HY1269 permit simultaneous application of all potentials. During stand-by, no precious filament current is drawn from the battery. Especially with the larger tube complements of FM transmitters, is conservation of battery power mandatory.

MORE OUTPUT—GREATER RANGE Only 4% of the current required for cathode types, is necessary to operate the instant-heating 2E25, HY69, and HY1269. (See table below.) Even in a mobile FM transmitter, 100 watts output is practicable. Imagine the advantages of such increased output in police, marine, or other mobile equipment.

SPARES PROBLEM SIMPLIFIED Using the 2E25, HY69, and HY1269, you take full advantage of the beam tetrode's versatility. The 2E25, for example, can power a whole transmitter—AF and RF—AM or FM. If more output is required, HY69's or HY1269's in push-pull still confine the spares complement to only two types.

ADVANTAGES OVER CATHODE TYPES Yes, the 2E25, HY69, and HY1269 cost more than cathode types. But they are worth it. Not only are they easier on the battery, and permit larger outputs, but they are designed, built, and tested for transmitting. Some advantages are: centering of filament potential at 6.0 volts, r.f. shielding to eliminate the necessity for neutralization, low-loss insulation throughout, plate connection to top cap, and rugged construction.

BATTERY DRAIN OF A CONVENTIONAL TRANSMITTER AND KAAR FM-50X EQUIPPED WITH HYTRON INSTANT-HEATING TUBES



This chart, prepared by Kaar Engineering Co., is based on typical metropolitan police use of 140 radiotelephone-equipped cars operating three shifts in a city of 600,000 population. The 24-hour survey included 904 messages originated by cars and 932 messages acknowledged by cars. Transmissions averaged: 13 per car, 15 seconds in length, and 3 minutes 15 seconds transmitting time.

ABBREVIATED DATA
HYTRON INSTANT-HEATING BEAM TETRODES

Characteristic	*2E25*	*HY69*	*HY1269*
Filament Potential (volts)	6.0	6.0	6/12
Filament Current (amps.)	0.8	1.6	3.2/1.6
Plate Potential (max. volts)	450	600	750
Plate Current (max. ma.)	75	100	120
Plate Dissipation (max. watts)	15	30	30
Grid-to-Plate Capacitance (mmfd.)	0.15	0.25	0.25
Maximum Seated Height (inches)	3 5/8	5 1/4	5 1/4
Maximum Diameter (inches)	1 7/16	2 1/16	2 1/16
Class C Power Output (watts)	24	42	63
Class C Driving Power (watts)	Less than one watt		

OLDEST MANUFACTURER SPECIALIZING IN RADIO RECEIVING TUBES

HYTRON
RADIO AND ELECTRONICS CORP.

MAIN OFFICE: SALEM, MASSACHUSETTS

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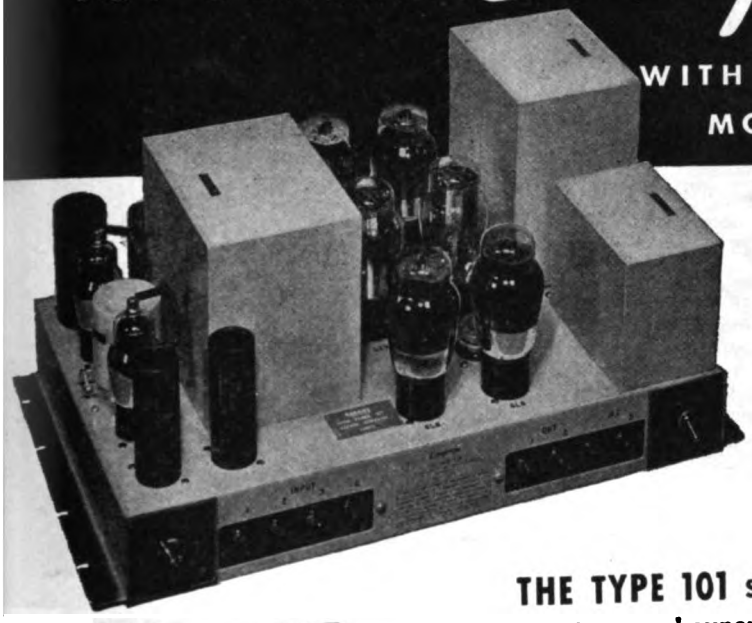
101 SERIES *Amplifiers*

WITH RACK PANEL OR WALL MOUNTING ACCESSORIES



Input impedance 600 ohms and bridging. Gain 600 ohm input 61 db., bridging input 46 db. Frequency response 30 to 16,000 c.p.s. either input—600 ohm output ±.5 db., 30 ohm output ±1 db. Power output—production run average: +47 V.U. with less than 3% RMS harmonic content.

THE TYPE 101 Series Amplifiers are the results of twenty years' experience in the sound engineering field. They are identical with the exception of the output coil.

Type 101-A has output impedance adjustments to match loads from 1 to 1000 ohms and possesses excellent low frequency waveform at high output levels.

Type 101-B with a single nominal 6 ohm output is intended for use with wide range loudspeakers representing an 8 to 16 ohm load. Its output coil with a single secondary provides improved efficiency and even better waveform at high levels of low frequencies.

Type 101-C answers the demand for a good amplifier at lower cost. This lower cost is obtained by the use of a less expensive output coil with the only change being that the low frequency waveform is not as good as the A or B types but is equal to or better than any contemporary commercial amplifier. Output impedance is adjustable to loads of 1 to 1000 ohms.

TYPE 201-A Wall Mounting Cabinet permits universal installation of 101 Series Amplifiers to any flat surface. Well ventilated and designed for maximum accessibility for servicing and convenience of installation. Standard aluminum gray finish.

TYPE 7-A Modification Group permits 101 Series Amplifiers to mount on standard 19" telephone relay racks. Occupies 12¼" rack space. Allows servicing from front of rack. Standard aluminum gray finish.

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Pre-Assembled TO REDUCE YOUR COSTS!

Also Available with Phillips Recessed Heads

SEMS

Trademark Reg. U. S. Pat. Off.

FASTENER UNITS

PRE-ASSEMBLED SHAKEPROOF LOCK WASHER AND SCREW

Assemblers simply pick up a Sems Fastener Unit and drive it! No need to put a lock washer on a screw because the Sems Unit is a combination of both. Thus an entire operation is eliminated . . . assembly speeds up, costs speed down.

Learn now—right on your own assembly line—the multitude of advantages that this modern fastening method offers you.

Shakeproof Engineers will analyze your particular fastening applications, recommend the correct type and size of Sems Unit and show your workers how they can easily and quickly reduce motions and gain vital assembly time. Ask for this special service today . . . a Shakeproof field engineer is ready to give you the benefit of his extensive fastening knowledge.

Get a Free Sems Fastener Unit Sample Test Kit
—Write for Kit No. 23

HERE ARE FOUR WAYS SEMS UNITS SAVE TIME AND MONEY

No time wasted putting a lock washer on a screw. Sems are delivered as a single unit—ready for immediate installation.

No dropped or lost lock washers. The lock washer on a Sems Fastener Unit can't drop off—but is free to rotate.

Easy to use in hard-to-reach parts. Sems Units assure fast assembly and there's no chance to "forget" the lock washer.

The right type and size lock washer for each connection. Important too, every Sems Unit includes a Shakeproof Lock Washer with Exclusive Tapered-Twisted Teeth.

SHAKEPROOF INC.

"Fastening Headquarters"

Distributor of Shakeproof Products Manufactured by ILLINOIS TOOL WORKS
2501 North Keeler Avenue, Chicago 39, Illinois
Plants at Chicago and Elgin, Ill. *In Canada: Canada Illinois Tools, Ltd., Toronto, Ont.*
Los Angeles Office
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Detroit Office
5895 E. Grand Blvd., Detroit 2, Mich.

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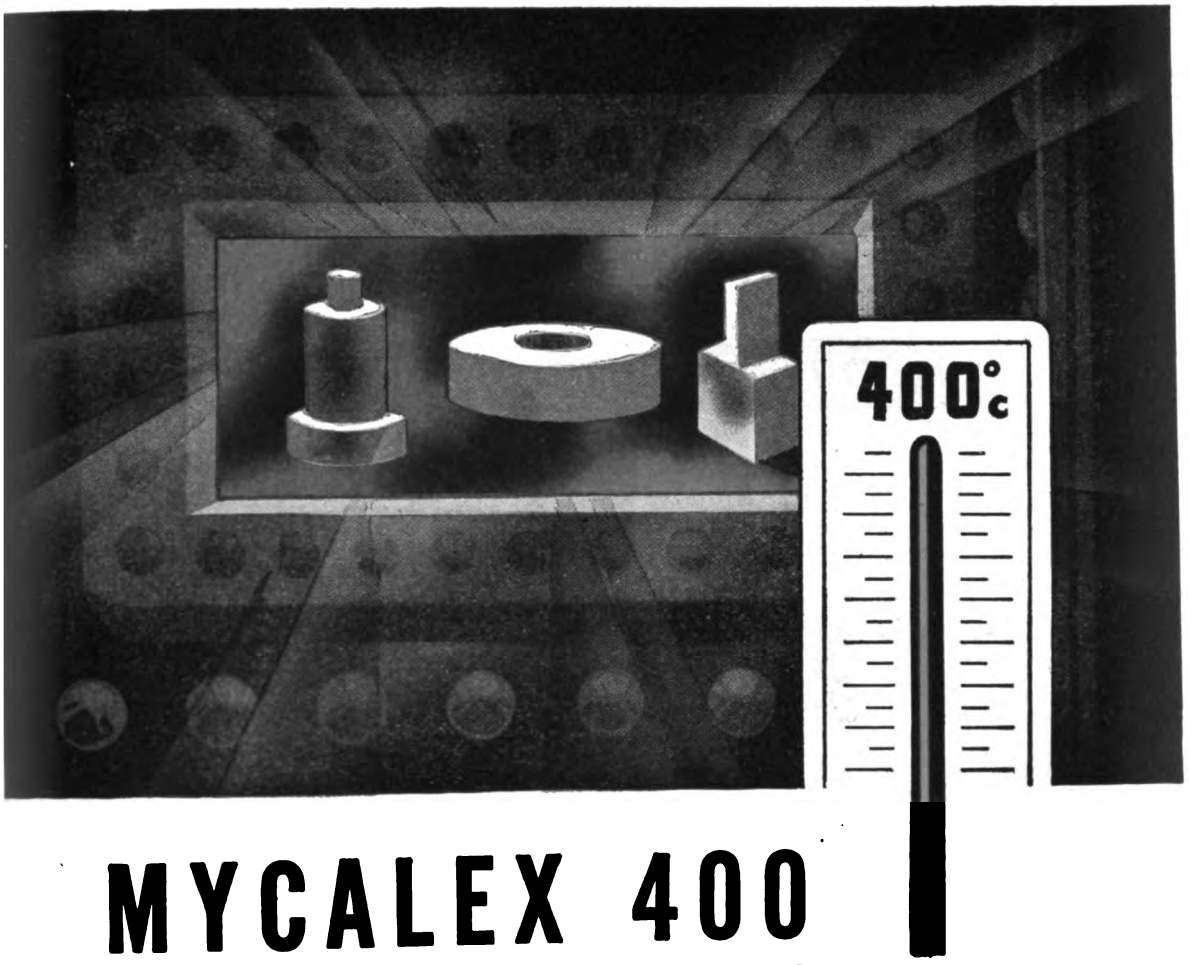

MYCALEX 400

WITHSTANDS HIGH TEMPERATURES

An outstanding characteristic of MYCALEX 400 is that it can withstand temperatures above 400° C. without softening or any permanent change in dimensions or properties.

Thus MYCALEX 400 has proved of great value as a low loss insulator in communications and other high frequency apparatus intended for use at elevated operating temperatures.

MYCALEX 400 is inorganic, free of carbonization . . . impervious to oil and water . . . not subject to cold flow. It meets all Army and Navy specifications as Grade L-4 material (JAN-I-10). It combines low loss factor with machinability to close tolerances. In sheets and rods. Fabricated to specifications.

SINCE 1919
MYCALEX
THE INSULATOR
TRADE MARK REG. U. S. PAT. OFF.

OTHER MYCALEX CORPORATION PRODUCTS

●

MYCALEX K

A series of ceramic capacitor dielectrics, with dielectric constant selectable from 8 to 19. Low power factor, high dielectric strength. Meets Army and Navy requirements as Class H material (JAN-I-12). To specifications.

MOLDED MYCALEX

Low loss, high temperature injection molded insulation. Molded in union with metals in irregular shapes. High production rates result in economical prices.

MYCALEX K and MOLDED MYCALEX will also withstand 400° C.

MYCALEX CORPORATION OF AMERICA

"Owners of 'MYCALEX' Patents"

Plant and General Offices, CLIFTON, N. J. Executive Offices, 30 ROCKEFELLER PLAZA, NEW YORK 20, N.Y.

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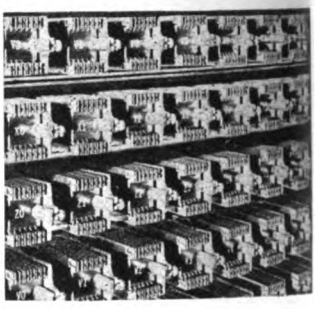
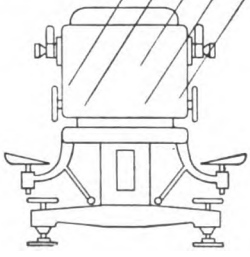
Target practice with Relays and Keys





(Left to right) The operator punches the problem data on tape, which is fed into the computer. The solution emerges in the teletype receiver. Relays which figure out the problem look like your dial telephone system.

In designing the gun-control systems which shot down enemy planes, Army ballistic experts were faced by long hours of mathematical calculations.

So Bell Laboratories developed an electrical relay computer. It solved complicated problems more accurately and swiftly than 40 calculators working in shifts around the clock.

Resembling your dial telephone system, which seeks out and calls a telephone number, this brain-like machine selects and energizes electric circuits to correspond with the numbers fed in. Then it juggles the circuits through scores of combinations corresponding to the successive stages of long calculations. It will even solve triangles and consult mathematical tables. The operator hands it a series of problems with the tips of her fingers — next morning the correct answers are neatly typed. Ballistic experts used this calculator to compute the performance of experimental gun directors and thus to evaluate new designs.

In battle action, Electrical Gun Directors are, of course, instantaneous. Such a director helped to make the port of Antwerp available to our advancing troops by directing the guns which shot down more than 90% of the thousands of buzz bombs.

Every day, your Bell System telephone calls are speeded by calculators which use electric currents to do sums. Even now, lessons learned from the relay computer are being applied to the extension of dialing over toll lines.

BELL TELEPHONE LABORATORIES

EXPLORING AND INVENTING, DEVISING AND PERFECTING FOR CONTINUED IMPROVEMENTS AND ECONOMIES IN TELEPHONE SERVICE

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Only CORNELL-DUBILIER could make this CAPACITOR

When a real capacitor problem arises, engineers turn to Cornell-Dubilier *first*.

For example: A recent large installation was planned involving thousands of KVA. Capacitors were required to operate continuously under unusual conditions with a maximum rise of 20° C.

C-D engineers went to work. They made a more compact capacitor capable of meeting all specifications and at the same time cut costs in half. The new units have been giving satisfactory service ever since their installation and more have been ordered by the same customer.

It is this special ability to tackle tough assignments and to come through with cost-cutting, "long-life" solutions that you obtain when you call on Cornell-Dubilier.

We are constantly developing new, exclusive designs like this giant mica tank capacitor — watch for others! For cooperation on your capacitor applications or special designs, write Cornell-Dubilier Electric Corporation, South Plainfield, N. J. Other plants at New Bedford, Brookline, Worcester, Mass. and Providence, R. I.

CORNELL - DUBILIER CAPACITORS

MICA · DYKANOL · PAPER · ELECTROLYTICS

New and improved design of oil filled industrial oscillator mica capacitor. Types 97A and 97B can handle a high KVA in one compact unit

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WL-889R

WL-889

WL-473

OSCILLATING

WL-892

WESTINGHOUSE

ELECTRONIC TUBES FOR ELECTRONIC HEATING

Westinghouse manufactures a complete line of electronic tubes that will meet your RF heating requirements. For descriptive data on any of the types shown, call your local Westinghouse district office or write:

Electronic Tube Sales Department,
Westinghouse Electric Corporation,
Bloomfield, New Jersey

WL-892R

WL-677

WL-678

CONTROLLING

WL-857B

WL-575A

WL-872A/872

RECTIFYING

TUNE IN: John Charles Thomas
—Sunday, 2:30 P.M., EST—NBC
Ted Malone—Mon. through Fri.,
11:45 A.M., EST—ABC

Westinghouse

Electronic Tubes at Work

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Eimac TUBES THE COUNTERSIGN OF DEPENDABILITY IN ANY ELECTRONIC EQUIPMENT

NEW EIMAC EXTERNAL ANODE TRIODE 3X2500A3

Rugged mechanical construction
Outstanding electrical efficiency

In the new 3X2500A3, Eimac engineers have developed a highly efficient external anode triode which, in Class C service, delivers up to 5 KW output at a plate voltage of only 3,500 volts. The mechanical design is radically simple, incorporating a "clean construction" which gives short, low inductance heavy current connections that become an integral part of the external circuits at the higher frequencies.

The external anode, conservatively rated at 2500 watts dissipation, has enclosed fins so as to facilitate the required forced air cooling.

Non-emitting vertical bar grid does not cause anode shadows ordinarily created by heavy supports in the grid structure.

Thoriated tungsten filament. Note unusually large filament area, and close spacing.

Filament alignment is maintained throughout life of the tube by special Eimac tensioning method.

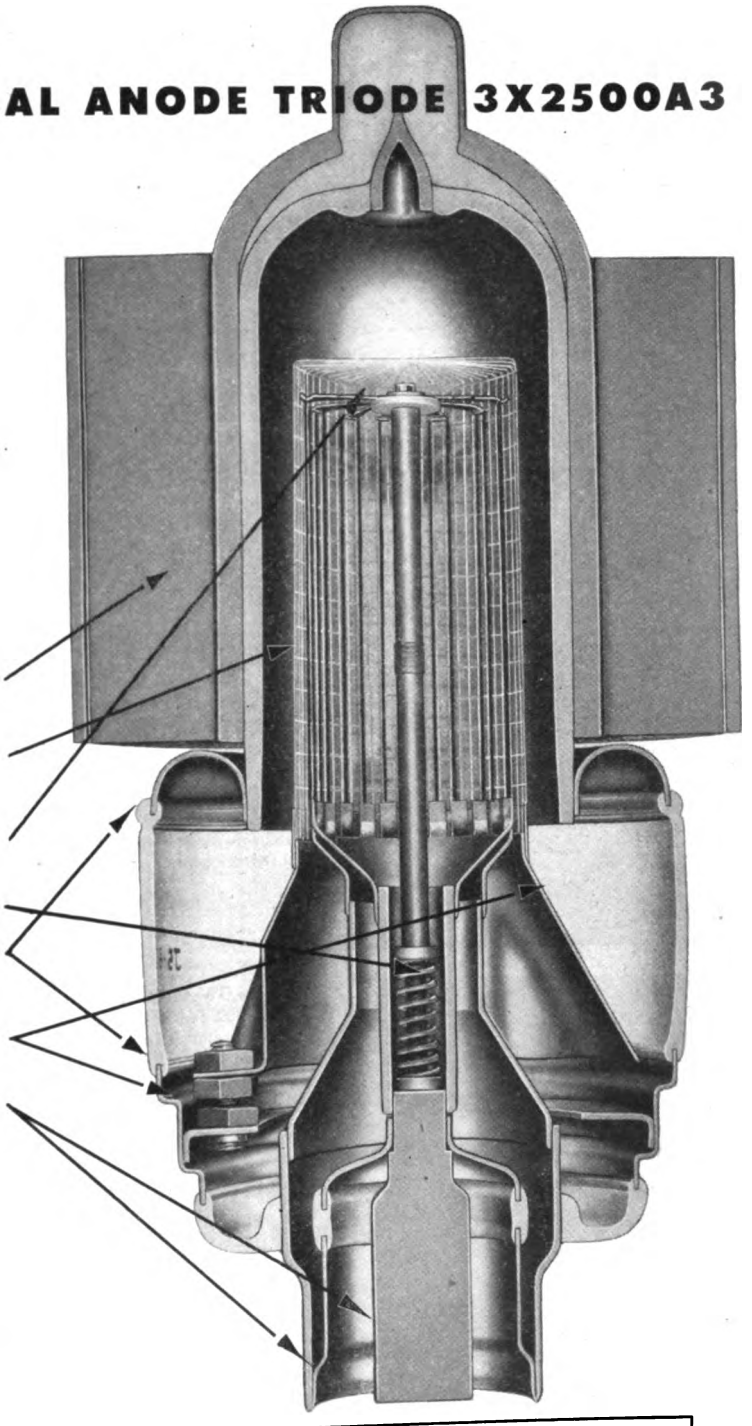
New glass-to-metal seals do not have the RF resistance common to iron alloy seals, nor the mechanical weaknesses of the feather-edged types.

Grid ring terminal mounts a cone grid support which acts as a shield between plate and filament.

A coaxial filament stem structure forms the base of the tube. This makes possible proper connections to the filament lines.

Grid and filament terminal arrangements make it possible to install or remove the 3X2500A3 without the aid of tools.

The new mechanical and electrical features of the Eimac 3X2500A3 external anode triode make it valuable for use on the VHF as well as low frequencies. More complete data and information yours for the asking.



TYPE 3X2500A3 — MEDIUM MU TRIODE

ELECTRICAL CHARACTERISTICS

Filament: Thoriated Tungsten	
Voltage	7.5 volts
Current	48 amperes
Amplification Factor (Average)	20
Direct Interelectrode Capacitances (Average)	
Grid Plate	20 μμfd.
Grid Filament	48 μμfd.
Plate Filament	1.2 μμfd.
Transconductance (i_B = 830 ma., E_B = 3000 v.)	20,000 μmhos

1123

FOLLOW THE LEADERS TO

Eimac TUBES REG. U.S. PAT. OFF.

EITEL-McCULLOUGH, INC., 1123 San Mateo Ave., San Bruno, Calif.

Plants located at: San Bruno, Calif. and Salt Lake City, Utah

Export Agents: [illegible] 301 Clay St., San Francisco 11, Calif., U.S.A.

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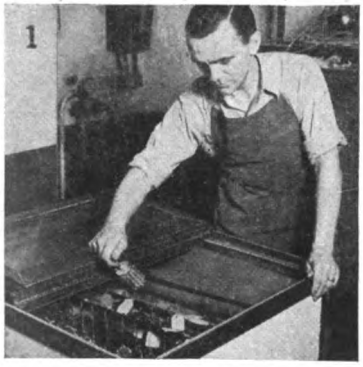
Pre-Testing of MALLORY SWITCHES Assures Precision Performance

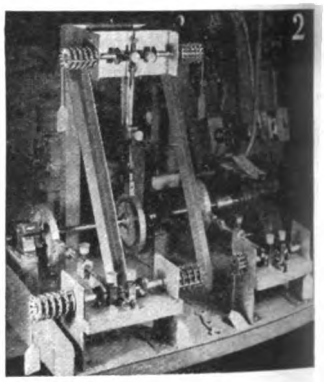
MALLORY has pioneered in developing new designs for both rotary and push-button switches, and in manufacturing them from improved materials. To make sure of the electrical performance and long life of these switches, Mallory puts them through punishing tests.

The complete line of Mallory *standard, pre-tested* precision switches and other electronic components is available from your nearest Mallory Distributor. See him today, and ask for your free copy of the Mallory catalog—containing specifications for switches, jacks, plugs, capacitors, resistors, rectifiers and other parts. Or write us today.

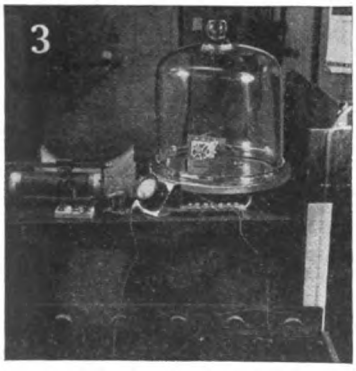
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA



1 SALT SPRAY TEST: In a few short hours, switches are subjected in this salt spray chamber to conditions that equal years of marine service.



2 SWITCH LIFE TEST: Hour after hour, this machine continues to operate the switch until it is destroyed. Results enable Mallory to develop switches with operating life exceeding normal requirements.



3 LOW ATMOSPHERIC PRESSURE TEST: The rarified air of the substratosphere is reproduced inside this large bell jar. Data from this test has aided Mallory in developing better switch construction for aircraft application.

4 FUNGUS CONTROL: In this laboratory, fungus cultures from the tropics are used in testing the fungicidal properties of new impregnating materials for the insulation in Mallory Switches.

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SCOVILL

FOR SPEED AND PRECISION IN THAT VITAL ASSEMBLY JOB

PLAN FASTENINGS NOW

"Cold-forging"—proof #35...more each month

Play Safe—Plan Today:

This period of increased competition demands fast, precise assembly, calls more and more for fastenings of special design.

Planning fastenings in the product-design stage may well solve your vital assembly problem. Early action enables you to make the exact choice—a featured standard fastening or a part especially designed to meet your specific requirements. No assembled product is better than its fastenings—and no fastenings are better than Scovill fastenings.

Play Safe—Choose Scovill:

Years of specialized experience in fastenings qualify us to help you make that exact selection—our demonstrated ability in special design* makes Scovill your logical choice.

This, plus our special processing, our ingenuity in cold-forging, means a substantial saving in *money—materials—motions.*

Call A Scovill Fastenings Expert Today

*Illustrated above is one of many special-purpose items—proof of Scovill ingenuity in cold-forging and ability in special design.

3 Standard Fastenings for Production Efficiency

1 Phillips Recessed Head Screws—The modern, effective, time-saving fastening device proven in tens of thousands of assembly lines. Other standard head styles are also available.

2 Self-Tapping Machine Screws—Eliminate separate tapping operations for fastenings to castings, heavy gauge sheet metal, and plastics. Also available with Phillips Recessed Head.

3 Washer-Screw Assemblies—When use of lock washers is indicated, the time-saving of pre-assemblies is obvious. Also available in standard slotted head styles.

SCOVILL MANUFACTURING COMPANY
WATERVILLE SCREW PRODUCTS DIVISION
WATERVILLE 48, CONN. TEL. WATERBURY 3-3151

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LOW FREQUENCIES

ACCURACY TO 1/1,000th of 1%

TOP
FREQUENCY STANDARD
(60 cycle) for use with external power supply

CENTER
CHRONOGRAPH
Records time intervals with resolution to .001 second

BOTTOM
FREQUENCY STANDARD
(120 cycles) with self-contained power supply

These tuning forks which include new engineering principles, provide frequencies from 120 to 1,000 cycles directly with an unqualified guarantee of accuracy to 1 part in 100,000 over a wide temperature range. (Better than 1 second in 24 hours). Closer tolerances are obtainable on special order.

These tuning fork assemblies are available only in single or multi-frequency instruments of our own manufacture which are designed to test, measure or control other precision equipment by mechanical, electrical accoustical or optical means.

The dependability of these frequency standards is being demonstrated for myriad purposes in all climates and under all working conditions.

If you have need for low frequency standards of exceptional accuracy, your inquiries are invited.

American Time Products, Inc.

580 Fifth Ave. **New York, N. Y.**

Dist. of Western Electric & Watch Master Watch-rate Recorders

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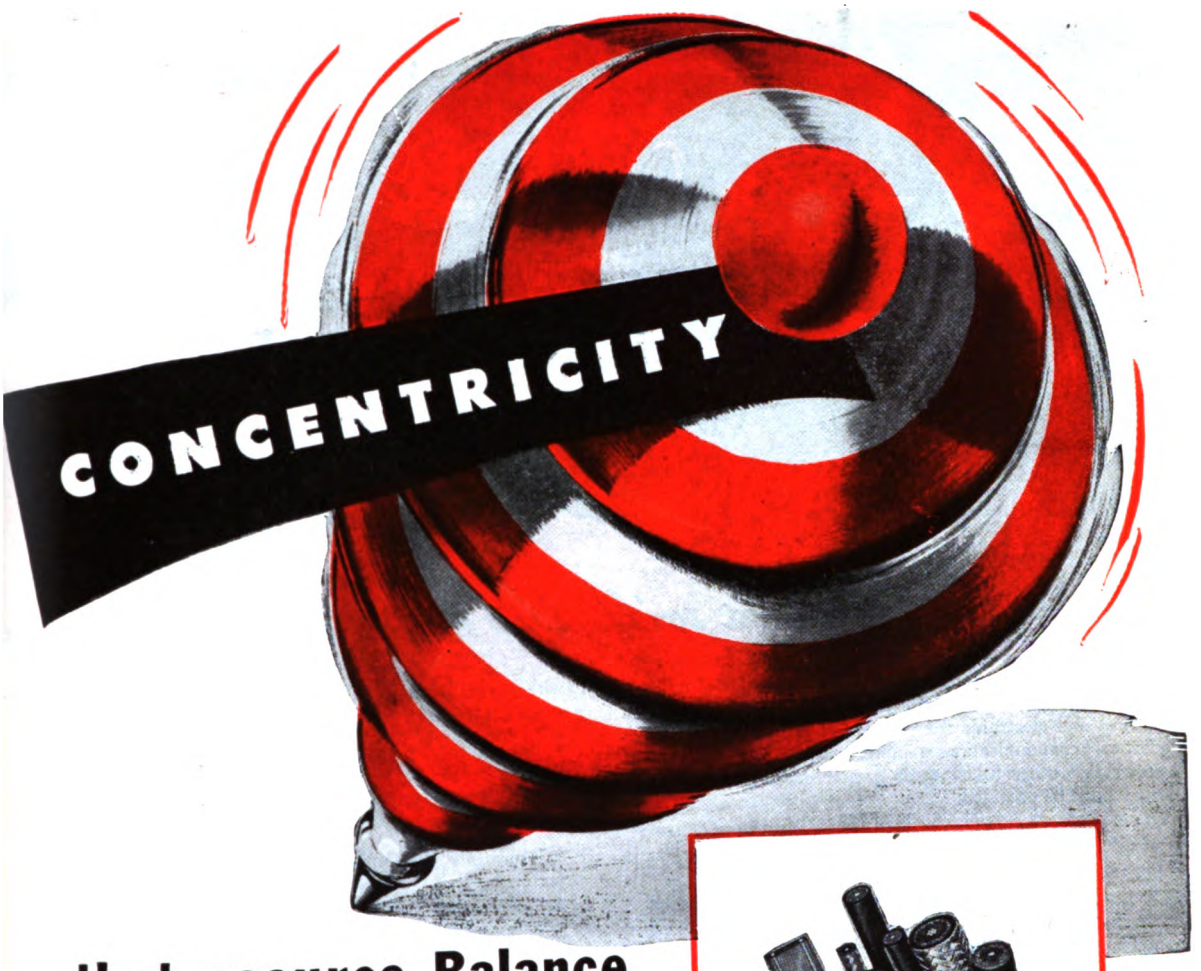

that assures Balance in High Frequency Lines

PRECISION MANUFACTURE is extremely important in all types of coaxial cables, especially where the success of complex networks depends on perfect balance.

The construction of Anaconda Coaxial Cables provides conductors not only symmetrically accurate, but ruggedly resistant to distortion and mechanical failure. Metal braiding is always substantially woven to prevent fraying and to stand up under continuous flexing.

In view of the rapid advancement in this field we offer engineering service for designing special types of low loss insulation cable.

48291

ANACONDA COAXIAL CABLES

Anaconda coaxial cables are made in many types to Army-Navy specifications.

ANACONDA

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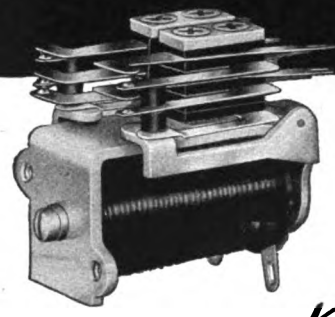
"AEROTROLS"



The Small Relays with the Big Performance

• Engineered and manufactured for the necessities of military aircraft operation, Cook "Aerotrols" have opened new fields in electrical and electronic remote control applications in radio-radar, wire communications, mining, manufacturing, testing and innumerable other fields where greater dependability and accuracy must be provided.

• Here are some of the general specifications of the "Aerotrol" "400" Series relays. The size of the "Aerotrol" without springs (the frame, coil and armature) is 15/16" wide, 1 7/16" long and 1" high. Spring assemblies add to overall height, up to 1" for 6 springs. Average weight for two spring pile-ups is 1¾ oz. The coil spool is one piece, moulded bakelite. Heel piece is arranged for two mounting screws with solder terminal for coil located at the armature end, at which end also, spring solder terminals are located. Coil winding capacity can be provided up to 10,000 ohms and for positive operation on current values as low as 2 milliamperes. Coil treatment normally includes impregnation with fungus lacquer and Insulex covering, and where required the coil is treated for high humidity and other tropical conditions.

• "Aerotrols" are small, compact, yet rigidly constructed relays that have proven their dependability, not only in laboratory tests, but in actual operation under the most severe wartime conditions all over the world.

• "Aerotrols" are "application engineered" to provide specific performance suitable to circuit and control conditions. There are many selective features that can be incorporated into these relays. Bushings and insulators can be provided made of Cook patented "Cecotite" ceramics, to provide freedom from carbonization and wear, and to provide permanent stability of original adjustment and rapid frequency of operation. Mounting arrangements can be provided to meet installation conditions, including the plug-in types.

• "Aerotrols" of various types, such as time delay, latching, A.C. or D.C., both single and double pile-ups, can be supplied.

Illustrated above is an "Aerotrol" heavy current relay, with two Form "A" contacts operating on a double armature.

SEND FOR BOOKLET AR-145 FOR INFORMATION ON THE COMPLETE LINE OF "AEROTROL" RELAYS.

Illustrated above is a latching type "Aerotrol" combining two type "401" "Aerotrols." Any combination of the "400" series relays can be combined into a latching "Aerotrol."

COOK ELECTRIC Company

Since 1897

CHICAGO 14, ILLINOIS

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Molding Plastics with Metal Inserts?

Electronic Preheating Can Help You

Users of this completely automatic RCA electronic preheater report production increases in usable molded parts of 50% to 500%! Cost reductions may pay for the equipment in a matter of months.

Wide experience of plastics molders shows electronic heat reduces rejects, simplifies molding, increases output 50%

If you are combining metal and plastics—if you are molding plastics parts with metal inserts—you'll find that electronic preheating can be of considerable help. Speedy electronic preheating provides almost amazing plasticity...allows you to mold at low pressure.

Because molding pressures are low, the danger of forcing inserts out of line is greatly reduced. Furthermore, the possibilities for mold damage are practically eliminated. Along with these important advantages, electronic preheating makes for a generally improved product and considerably increased production rate.

If you are a molder, RCA engineers will gladly advise you on the proper equipment and procedures to use in obtaining improved results with electronic preheating. You will find greatly increased production, and lowered over-all costs. Records kept by molders using electronic preheating show production increases of usable parts as high as 500%, and cost reductions of at least 50%—all costs included. Send the coupon below for details.

If you are a plastics buyer and do not do your own molding, ask the custom molder who serves you about electronic preheating. He may be able to solve a problem for you by the use of electronic preheating. A recent survey conducted for RCA among plastics molders shows that an overwhelming majority of those questioned prefer electronic preheating as the Number One method of preheating because it gives a better molded product at higher production rates.

RCA Electronic Heating Equipment specially designed for the plastics industry offers a combination of advantages obtainable from no other manufacturer. The pace-setting RCA 2000-watt unit (Model 2B) has set the design standard for the industry. Completely automatic, it can turn out a pound of uniformly heated preformed material at 275°F in only *40 seconds*—25% to 50% faster than non-automatic units. Operating cost (including tubes, power, maintenance, and depreciation) is as low as 20 cents per hour! Send coupon for free bulletin. Write details of your plastics-molding problem to RCA application engineers. Address: *Radio Corporation of America, Electronic Apparatus Section, Box* **70-204H** *Camden, N. J.*

RCA ELECTRONIC HEAT

RCA

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION . CAMDEN, N. J.

MAIL COUPON TODAY

FREE BOOKLETS ON PLASTICS PREHEATING:

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Box 70-204H, Camden, N. J.

Please send me free information on improved plastics molding with economical RCA electronic heat.

"Electronic Heat Speeds Plastics Molding"
"RCA Electronic Generator—Model 2B—For Plastics"
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City.....Zone.....State.....

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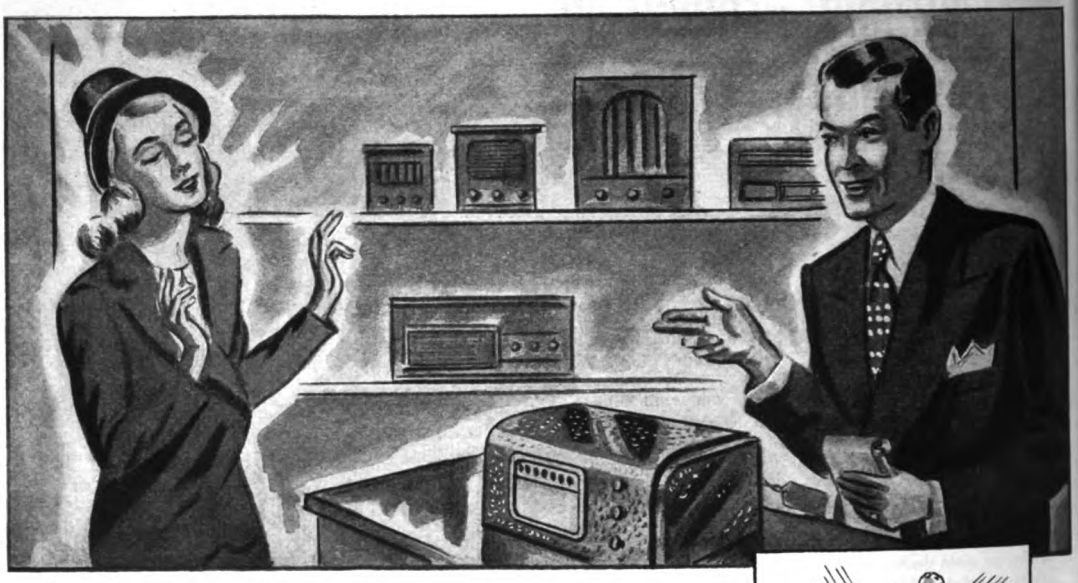
REMEMBER-
AT THE POINT OF SALE-
"Eye Appeal Means Buy Appeal!"



She's buying a new radio—one of the many post-war items that all America is hungry for. Your name on the set will be sufficient guarantee of good workmanship and dependability, but she's going to ask for more than that! She's going to demand a thing of beauty—an object that will be an attractive addition to her home.

M & W's Hammertone finish will provide that beauty and give your product a high degree of eye appeal at the point of sale. Hammertone is a tough, durable finish which simulates hammered metal. It is available in silver, copper and many other colors for use on metal, plastic or wood products.

For information on Hammertone or any of the other many M & W industrial finishes, contact the branch office nearest you or write direct to

WE ARE HEADQUARTERS FOR SOLVING INDUSTRIAL FINISH PROBLEMS!

Have you a special finishing problem? Let us develop the right finish to meet your requirements.

MAAS & WALDSTEIN COMPANY, NEWARK 4, N. J.

PRODUCERS OF LACQUERS, ENAMELS, SYNTHETICS AND SPECIALTY FINISHES FOR ALL PURPOSES

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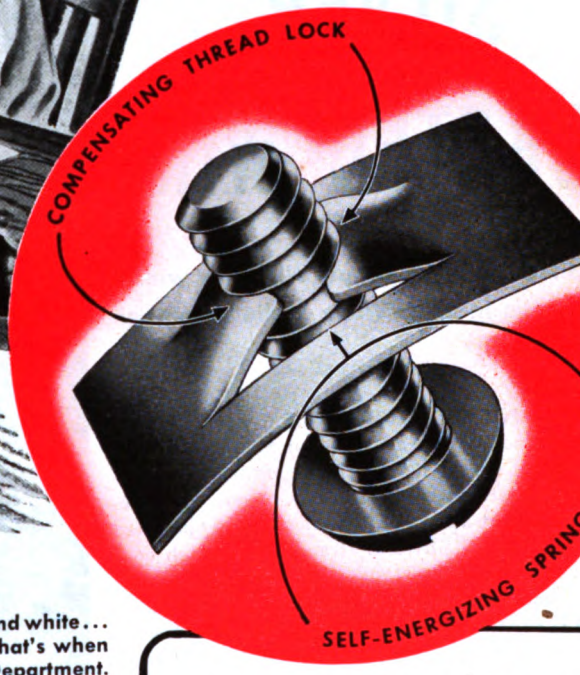
WHY SPEED NUTS ARE FI

with Time Study and Cost Departments



When ALL assembly costs are down in black and white... when TOTAL net assembly costs are figured... that's when SPEED NUTS really show results in the Cost Department.

For SPEED NUTS reduce assembly costs in many ways. They completely eliminate lock washers—saving the cost of the washers *and* the time necessary to handle and install them. Moreover, hundreds of SPEED NUTS have been designed to perform multiple functions and eliminate two or more assembly parts.

SPEED NUTS are applied faster and easier to speed up assembly. They can't "clog" with paint or enamel to delay the assembly line. "Self-retaining" types of SPEED NUTS do away with expensive welding and clinching operations. And SPEED NUT spring-tension resiliency also protects porcelain, plastic or glass parts against damage in transit.

A letter describing your fastening problem will bring you full details on how SPEED NUTS will reduce YOUR total net assembly costs, too.

NOTHING LOCKS LIKE A SPEED NU

Only SPEED NUTS provide a COMPENSAT ING thread lock and a SELF-ENERGIZING spring lock. As the screw is tightened th two arched prongs move inward to loc against the root of the screw thread. Thes free-acting prongs COMPENSATE for toler ance variations. Compression of the arch i prongs and base creates a SELF-ENERGIZ ING spring lock. These two forces combin to definitely prevent vibration loosening

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In Australia: Simmonds Aerocessories, Pty. Ltd., Mel

Speed Nuts PATENTED

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SILVER JACKETED WIRE

WILCO Silver Jacketed Copper Wire now widely used for coils in Short Wave Radio Communications Systems.

PROPERTIES AND CHARACTERISTICS—WILCO Silver Jacketed Copper Wire—an economical non-corrosive wire with solid-silver characteristics—is used successfully in many *electronic* applications, where high frequency currents are a problem. Another WILCO jacketed type combines great physical strength with high conductivity. A third unites stamina with highly desirable electrical characteristics. In fact there is almost no limit to WILCO facilities for combining metals of widely differing physical and electrical properties to meet individual engineering needs.

Gold, silver, copper, brass, bronze, iron, steel, nickel, monel and invar, are all utilized in producing WILCO'S uniform, non-porous, securely bonded jacketed wire and rolled strip.

CONSULT OUR ENGINEERING DEPARTMENT—Write our Engineering Department for help in developing the proper application of WILCO materials to your products.

SEND FOR WILCO BLUE BOOK—The Blue Book contains charts, formulae and full descriptions of *all* Jacketed Materials and other WILCO products. Send for FREE copy today.

WILCO PRODUCTS INCLUDE:

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Silver
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EQUIPMENT FOR THE AIRLINE GROUND STATION

MR-71B RECEIVER

- DUAL CHANNEL
- FIXED FREQUENCY

Now—a *new* Bendix Radio Receiver engineered for the airline ground station and designed for V.H.F. (Very High Frequency) fixed frequency radio reception.

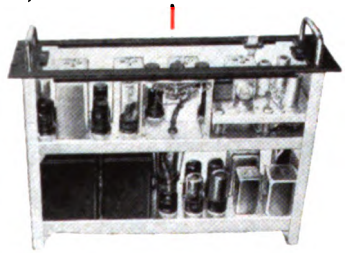
Built to the quality requirements that have made Bendix Radio products "Standards for the Aviation Industry," the MR-71B V.H.F. Radio Receiver functions on a frequency range of 118-132 Mc.—

—provides dual channel operation, extreme sensitivity, high selectivity, excellent stability.

—incorporates positive squelch operation, rapid amplified AVC, and effective noise limiter.

—engineered so that all adjustments are available from front panel without removing unit from its rack.

For full information as to dimensions, weight, construction, electrical characteristics and service features, write the Sales Department, Bendix Radio Division, Baltimore 4, Maryland.



Bendix Radio DIVISION

BALTIMORE 4, MARYLAND

BENDIX RADIO

PRODUCT OF Precision Equipment Bendix AVIATION CORPORATION

STANDARD FOR THE AVIATION INDUSTRY

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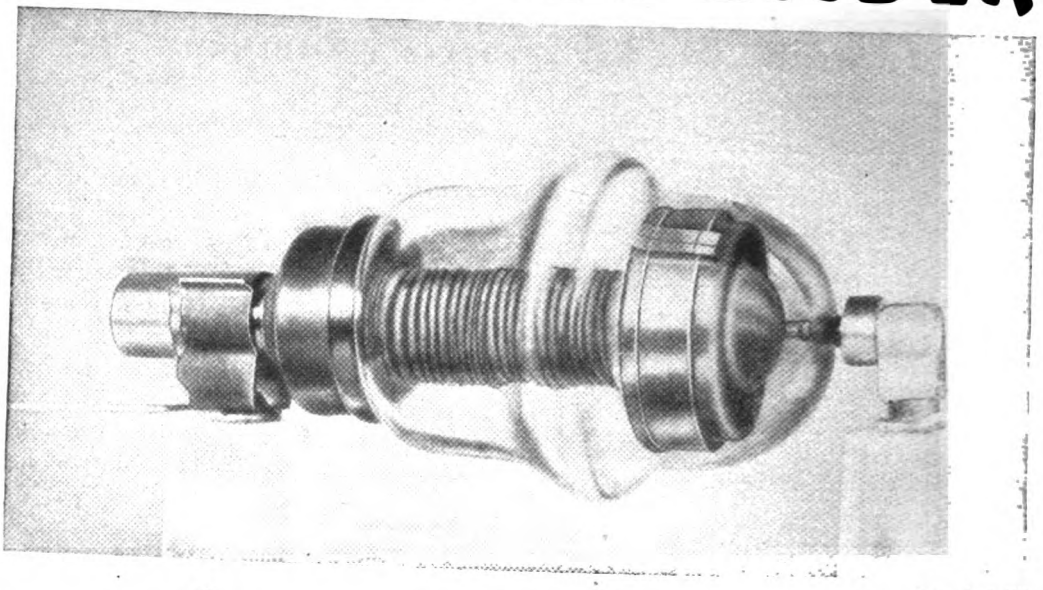
Jennings
RADIO
VACUUM ELECTRONIC COMPONENTS

Vacuum Variable CONDENSER!



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at Last—

After three years of development, Jennings has brought the **first** successful **Vacuum Variable Condenser** to the Electronic field.

For improved efficiency, reduced size and weight, these units should be used in tank, neutralizing or antenna tuning circuits in FM, AM and Television stations. Write for further details on this remarkable unit and other Jennings High Voltage Vacuum Capacitors in a wide range of sizes and capacities.

We welcome your inquiry and the opportunity to serve you.

WATCH JENNINGS FOR NEW DEVELOPMENTS IN THE FIELD OF SPECIALIZED VACUUM ELECTRONIC COMPONENTS.

WRITE FOR BULLETIN E

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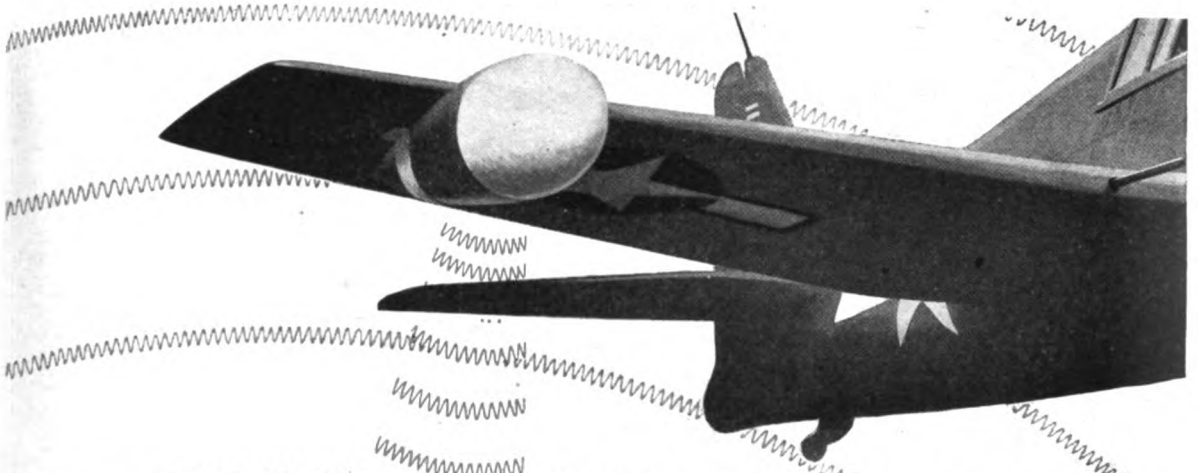


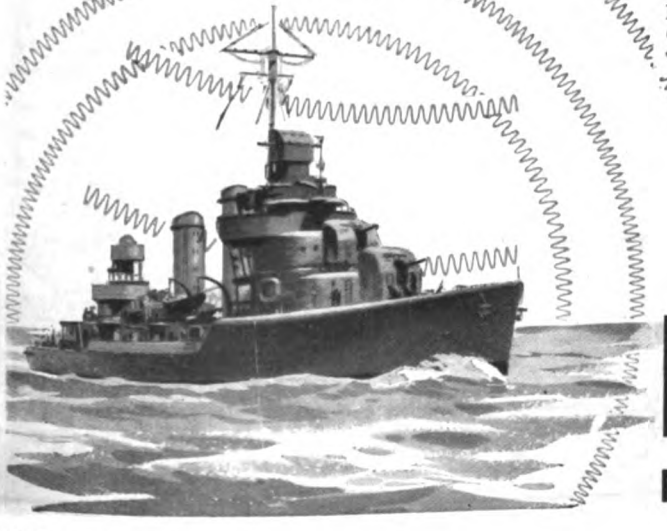
PRESENTING THE CASE FOR RADAR

AS THE STORY of radar unfolds, the nation becomes increasingly aware of the extreme importance of this one-time "secret weapon." And behind *that* story is another—about radically new types of housings that had to be developed before radar could perform its vital functions on land, at sea, and in the air . . . housings called radomes.* Certain types, such as the radome illustrated, were produced from woven glass cloth and BAKELITE laminating resins.

Manufacturers, designers, and engineers will be interested in the exceptionally exacting requirements that were met: low power factor and low dielectric constant at high radio frequencies; high tensile, flexural, and compressive strengths; and extreme weatherability. Still other advantages of this new and superior electrical insulating plastic included good color stability and resistance to marine growths. Productionwise, these laminated radomes were formed at low fabricating pressures, in comparatively inexpensive molds. They demonstrate the practicality and economy of forming large, intricate shapes by this laminating-molding technique at pressures frequently as low as one pound per square inch.

Write Department 68 for further information on BAKELITE resins for high-, low-, and contact-pressure laminating, and the names of the suppliers of the finished laminates.

*Radome illustrated through courtesy of Andover-Kent Aviation Corp.



TRADE (B) MARK

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BAKELITE

TRADE-MARK

LAMINATING PLASTICS

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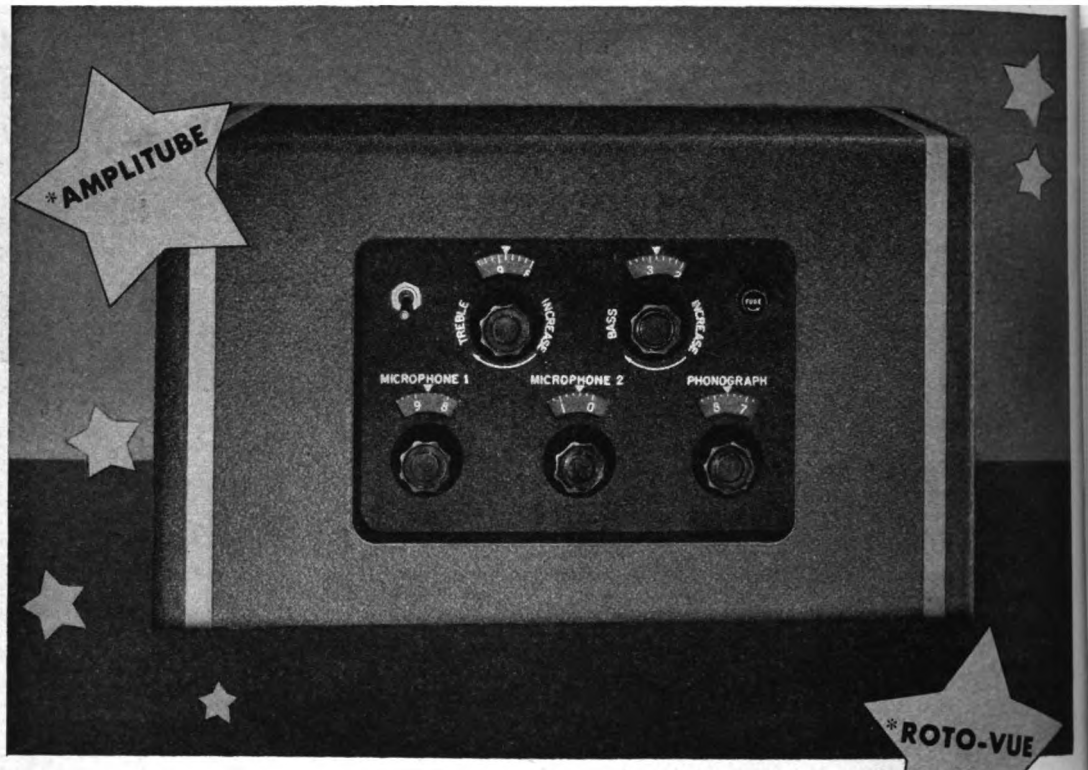

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Ethical engineering at Eastern is the history of many years in the service of sound amplification. The 21 Star Features are the result of intensive experience dating back to the early days of radio—the pioneer 20s! Today this engineering background accounts for the many innovations we have designed for the new 1946 Eastern Amplifiers—the 21 Star Features that produce Eastern's famous *Quality Performance.* No other amplifiers, regardless of price, incorporate so many novel and useful features. . . . For complete information and price list—for the first edition of our 1946 Catalog—write today! . . . Eastern Amplifier Corporation, 794 East 140th Street, New York 54, N. Y. Dept. 12F.

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"Dag" products are versatile. Dispersed in numerous liquids, they're doing a good job over a wide range of industry for regular production.

Some "dag" suspensions, hitherto not available, were developed during the war. Available for you now, they broaden the usefulness of already broadly used "dag" colloidal graphite. You too may save yourself worry and money by writing today for full information about the "dag" family of dispersions.

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- 430 — A general booklet on the story of "dag" colloidal graphite. 12 pages profusely illustrated.
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No. 431 ☐ OUR PRESENT OIL SUPPLIER IS _____
No. 432 ☐ (Lubricants containing "dag" colloidal graphite are available from major oil companies.)

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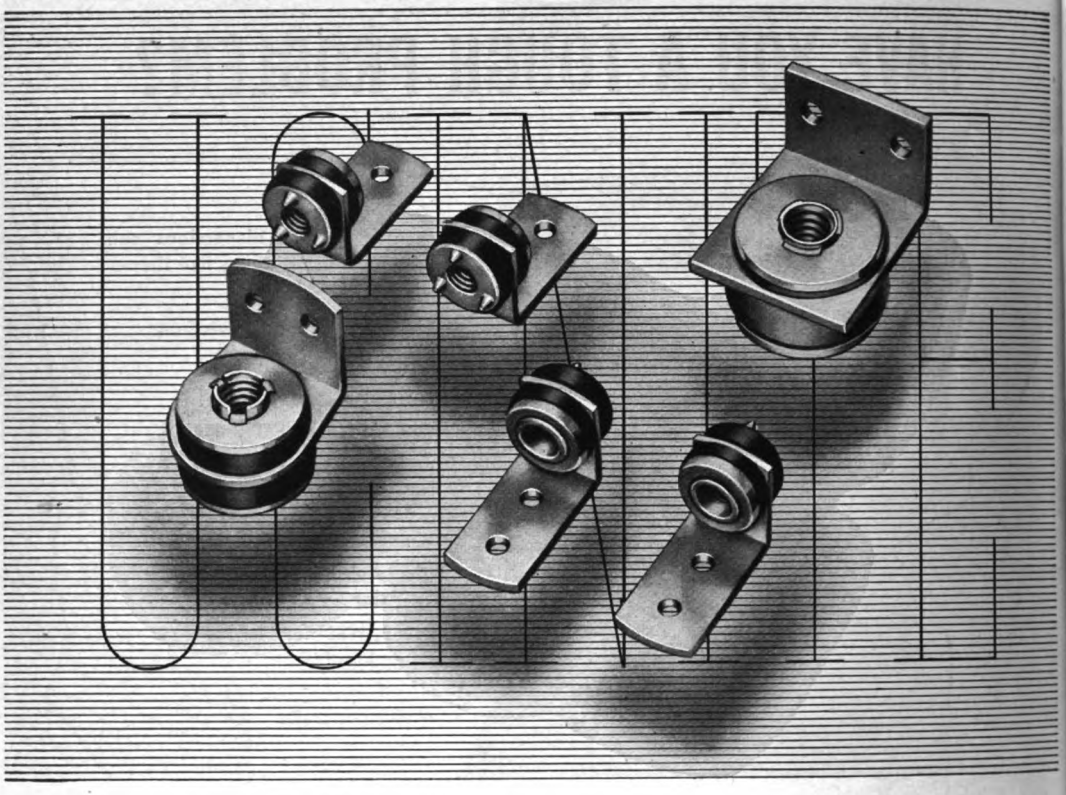

Their uses are mounting, too

These Ucinite shock mountings have a self-contained Tee Nut. Set in a synthetic rubber ring of great toughness and resilience they are extensively used as shock-proof mountings on Service radio sets. They have stood up successfully under severe tests of shock, temperature and climate.

Other industrial peacetime applications such as electrical condensers and phonograph turntables immediately suggest themselves.

The mountings shown here are only one general type of the basic design which can be adapted in a wide variety of applications for other requirements.

The UCINITE CO.

Newtonville 60, Mass.

Division of United-Carr Fastener Corp.

***Specialists in* RADIO & ELECTRONICS**

LAMINATED BAKELITE ASSEMBLIES

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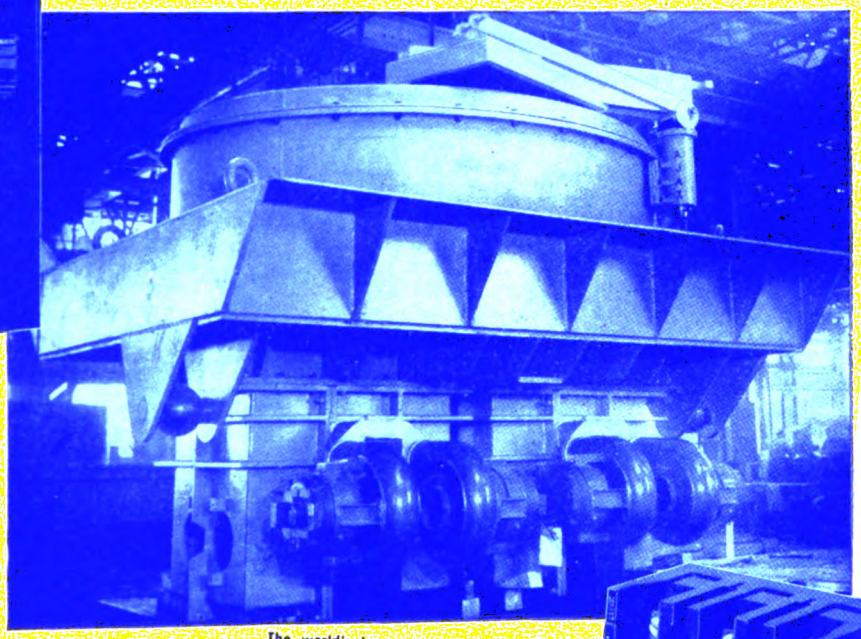
MAGNETIC CIRCUIT BREAKERS
PREVENT POSSIBLE DAMAGE
From Short Circuit or Dangerous Overload
to Blower Motors
In This AJAX ELECTRIC FURNACE

Control cabinet containing HEINEMANN three phase, 230 volt Circuit Breakers.



The world's largest low frequency induction furnace for melting aluminum and aluminum alloys.

Immediate and dependable protection of the blower circuits is of the utmost importance for a unit such as this 500 KW Ajax melting furnace. The Ajax Engineering Corporation, realizing the flexible but unfailing protection afforded by HEINEMANN CIRCUIT BREAKERS, included them in their specifications.

In the words of an Ajax engineer, "Protection of the blower motor against overloads and short circuits is most essential. Magnetic protection also permits quick re-cycling, which is just as important."

Although tripping instantaneously on short circuit or dangerous overload, the HEINEMANN Magnetic CIRCUIT BREAKER provides a delayed trip on minor overloads, in inverse ratio to current.

Send for NEW Catalog Showing Complete Line and Engineering Data.

HEINEMANN CIRCUIT BREAKER CO.

Subsidiary of Heinemann Electric Co., Est. 1888

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DOWN through the years with Radio—right from the very beginning—STERLING has built specialized apparatus for the Radio market and at times—complete Radio sets for world-wide distribution . . . Millions of STERLING products, battery eliminators, chargers, testers, have played a vital part in the development of Radio . . . Our wartime operations are now ended . . . Post-war products will reflect STERLING'S 39 years of successful electrical manufacturing experience.

The Sterling Manufacturing Company *9502 Detroit Avenue Cleveland, Ohio*

ELECTRICAL MANUFACTURERS FOR 39 YEARS

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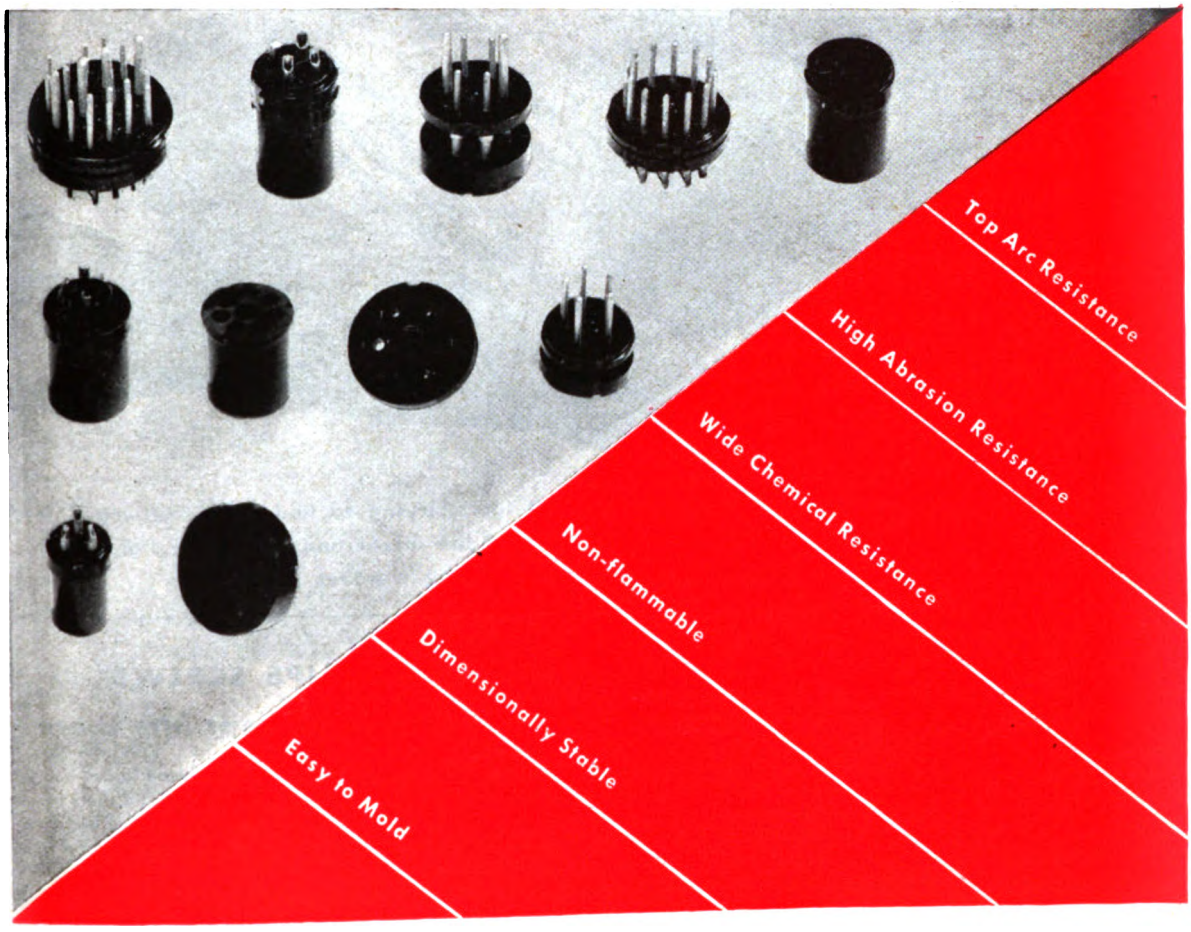
RESIMENE* 803A



Here is a cellulose filled melamine molding compound which combines characteristics which you may need. Resimene 803A has high arc resistance—125 seconds, which means long life in any part where arcing or flash-over is met. More stamina can be built into switch bases, connectors, plugs and other electrical parts with this important advantage.

But that is not all Resimene 803A offers . . . its abrasion resistance is higher than cellulose filled phenolic . . . it has higher alkali resistance than most thermosetting plastics and, in addition, it's not attacked by weak acids, most organic solvents or boiling water. These properties are combined in a molding compound of excellent moldability and good physical properties formerly expected only with general purpose phenolics. After-shrinkage of Resimene 803A is considerably less than any similar material . . . Resimene 803A is being produced only in black and olive drab.

* * *

For full details and advice, write MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts.

The broad and versatile Family of Monsanto Plastics includes: Lustron polystyrene • Cerex* heat resistant thermoplastics • Vinyl acetals • Nitron* cellulose nitrates • Fibestos* cellulose acetates • Resinox* phenolics • Thalid* for impression molding • Resimene* melamines • Forms in which they are supplied include: Sheets • Rods • Tubes • Molding Compounds • Industrial Resins • Coating Compounds • Vuepak* rigid transparent packaging material.

*Reg. U.S. Pat. Off.

MONSANTO PLASTICS
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He was always "4-FOOTED FRED"

... always down on all fours, trying to find those slithery slotted screws that skid off the driver and roll out of sight. Fred lost hours this way—as well as scores of screws—

...until AMERICAN PHILLIPS SCREWS put him back on his feet—*and kept him there*

Every time Fred fits an American Phillips Screw on the 4-winged bit of his power driver—he's a sure shot to make a swift, straight, secure fastening. For these recessed-head screws *stay aligned* with the driver till the heads are turned up flush. There's no open-end slot to let the driver skid out... instead, a 4-winged recess that encloses the driver completely, and holds it secure in a *tapered* grip.

So no time is lost in hunting for dropped screws... and none lost in slow starts, "drunken driving," or filing mangled screwheads. For American Phillips Screws drive straight every time, and their heads can't burr or split. This means total time-savings up to 50%—*which means that American Phillips Screws COST LEAST on any assembly job.*

Make a note, now, to mark your orders: "*American* Phillips Screws." For then you get the extra value-protection of American's 4 inspections, and automatic weigh-count... plus prompt delivery from ample American warehouse stocks.

AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

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Television Tubes
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Visitron **is not a new name in tubes.** ***Visitron*** **is Rauland's name for all electronic tubes made in the Rauland Tube Division. It is the mark of the advanced** ***Rauland*** **Television thinking and planning based upon a pioneering experience second to none.** ***Rauland Visitron*** **tubes for direct-viewing for the home and projection for the home and theatre are ready to take their places in the new era of Television entertainment now unfolding before us.**

To be sure of your tube, be sure it's "*Visitron*."

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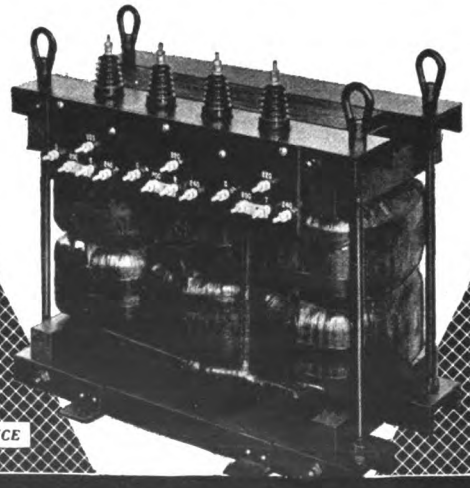
FOR NEARLY 20 YEARS, the Kenyon Transformer Company has done an outstanding job of satisfying the demand of large manufacturers for "special units" to fit exactly their most critical needs, with the same care that other manufacturers could provide items of their standard catalog lines.

THIS ACHIEVEMENT is a tribute to the skillful engineering ability of the Kenyon Pioneers who have maintained a leading place in the development of outstanding transformer equipment.

WE INVITE INQUIRIES from manufacturers of electronic and other types of equipment, and from industrial and commercial users of transformers.

KENYON PREDICTS that the small additional cost of "specials" will be more than offset by the superior product—streamlined to fit each manufacturer's requirement.

Inquiries invited — write for our new 1945 ILLUSTRATED CATALOG.



THE MARK OF EXCELLENCE

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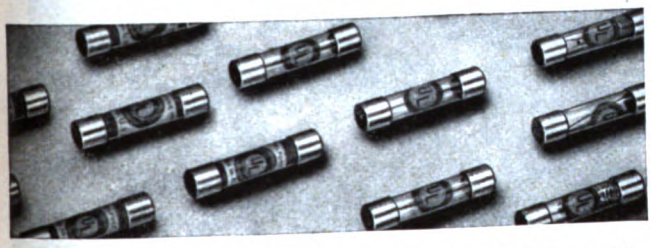
LITTELFUSE

3 AG and 3 AB Fuses



Littelfuse, the first manufacturer to receive Underwriters' Approval on glass-enclosed fuses in current ratings over 3 amps at 250 volts NOW has Underwriters' Approval on fibre-enclosed fuses from 10 amps to 20 amps at 250 volts.

These 3 AB "TINY MIGHTY" fuses (1¼x¼ dia.) will take the place of bulky cartridge or plug fuses and mountings used in heavy-duty electric appliances, power supplies, amplifiers, communications and electronic equipment, radio, motor circuits, etc. To reduce fusing space and weight get approved protection with 3 AG and 3 AB "TINY MIGHTY" Littelfuses.

Ranges of Underwriters' Approved 3 AG Littelfuses, 1/16 amp to 8 amps inclusive; Underwriters' Approved 3 AB "TINY MIGHTY" Littelfuses, 10 amps to 20 amps inclusive at 250 volts or less.

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QUALITY SERVES

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True service demands the best quality.

President

LITTELFUSE *Incorporated*

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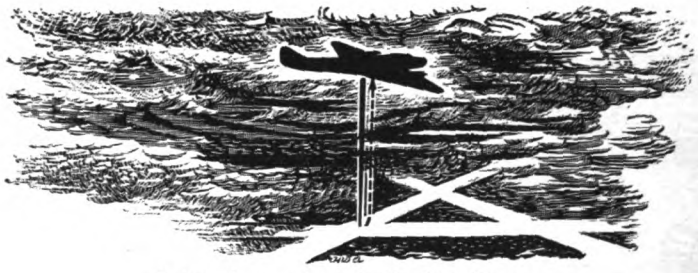
Points the way through cloud-hidden mountains

Points the way through fog-bound shipping lanes



Points the way for safe blind landings

Points out night-shrouded icebergs

In War or Peace

NICKEL *helps* RADAR

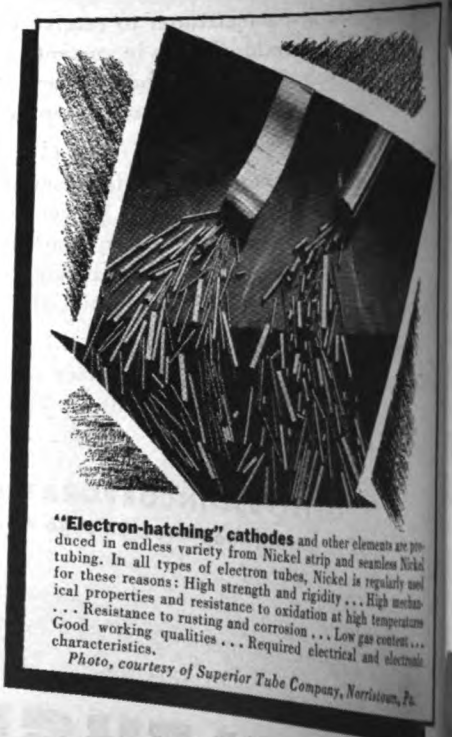
POINT THE WAY

Nickel plays an important role in radar.

The tell-tale stream of electrons is fed to the cathode-ray screen from a pure Nickel cathode. *That's practically "standard" in all radar equipment.*

No other commercial metal offers so favorable a combination of electrical and electronic properties . . . plus the ability to be worked in such small sizes.

The multiple advantages of Nickel and high-Nickel alloys make them particularly useful in many additional radar and other still-secret applications where strong, corrosion-resistant materials are needed with special electronic or electrical properties. Send for your copy of "Nickel in the Radio Industry." The International Nickel Company, Inc., 67 Wall Street, New York 5, N. Y.



"Electron-hatching" cathodes and other elements are produced in endless variety from Nickel strip and seamless Nickel tubing. In all types of electron tubes, Nickel is regularly used for these reasons: High strength and rigidity . . . High mechanical properties and resistance to oxidation at high temperatures . . . Resistance to rusting and corrosion . . . Low gas content . . . Good working qualities . . . Required electrical and electronic characteristics.

Photo, courtesy of Superior Tube Company, Norristown, Pa.

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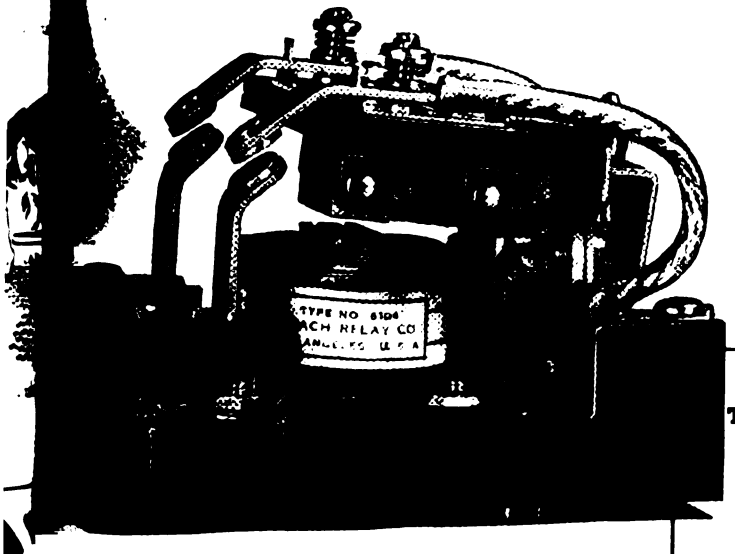
Relays
BY
LEACH



THE NEW 30 AMPERE RELAY

- ✓ Moulded bakelite base.
- ✓ Laminated core and armature
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- ✓ Rated 30 Amps. at 110 V.A.C.
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● *All the engineering skill that has created for Leach its reputation as manufacturers of fine relays is at your service. Our Engineering Department will be glad to discuss with you any problems which you may have. Write for literature.*

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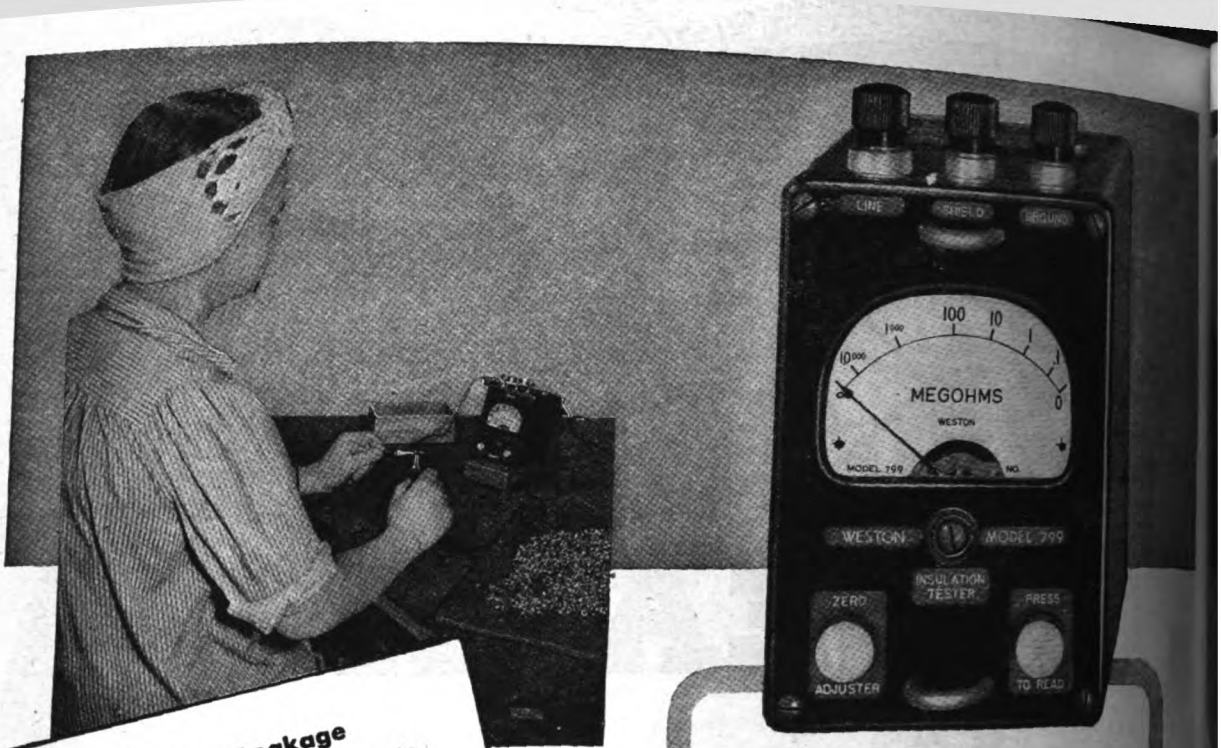

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Because of its compactness and extreme high sensitivity, this direct reading instrument fills an important measurement gap in the production and servicing of a wide variety of components and electrical devices. Minute faults can be detected *in advance* . . . tests can be made without destructive breakdown. Test potential less than 50 Volts.

Here's what a few typical users say about Model 799:

"We use it for testing the leakage between windings in transformers, or from windings to core or case."

"We can test the leakage of low voltage paper and mica condensers with the 799, and without danger of damaging the dielectric."

"We test leakage resistance between individual wires in cable harnesses."

"Model 799 is also ideal for checking leakage due to moisture in fiber terminal strip."

For complete data on Model 799 Insulation Tester, communicate with the WESTON representative in your locality, or write...Weston Electrical Instrument Corporation, 618 Frelinghuysen Ave., Newark 5, N.J.

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MODEL 799

INSULATION TESTER

• 10 BILLION Ohms •

will measure:

- ✓ **Insulation Properties**
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SPIRAL CAM FASTENERS SERVE THE ELECTRONIC INDUSTRY

Just a quarter turn with a coin or screw driver and — click — the Dzus spiral cam fastener is firmly locked or quickly unfastened.

Navy's New Collins Autotune Transmitter — the versatile radio used on most two-place and larger types of naval aircraft — is equipped with flush head type Dzus spiral cam fasteners.

Photos, Collins Radio Co.

Flush head fastener stud

Grommet

Spring

Cut-away view of complete Dzus spiral cam fastener assembly

Radio and electronic manufacturers find that quick-acting Dzus spiral cam fasteners have all the qualifications to meet rigid specifications and requirements for firmly holding hinged or removable parts. This fastener is light but rugged, vibration-proof and permanently attached. It is easy to install and operate. It saves valuable time, especially with equipment that requires periodic inspection and adjustment.

There is a Dzus spiral cam fastener for every requirement in the electronic industry — supplied in various sizes and head styles. Send for the Dzus catalog today—and have at your fingertips the most complete line of self-locking fasteners available.

* The word DZUS is the registered trade mark of the Dzus Fastener Company, Inc.

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BABYLON NEW YORK

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BY

FOSTER

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During the war years A. P. Foster has supplied thousands of custom-designed and custom-built transformers to all branches of our armed services, for use in all parts of the world under great extremes of climatic condition.

High production schedules have been maintained by advanced Foster manufacturing techniques. High standards of performance were demanded, achieved and will be maintained—to the benefit of America's peacetime economy.

As your own reconversion plans advance from the conference stage to the blueprint stage, it may well be worth your while to bear in mind that Foster engineers and designers are ready *now* to consult with you on every transformer problem and to furnish estimated costs and delivery schedules on experimental or quantity production of standard transformers or special jobs custom-built to your own specifications.

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- BAUMAN AND BLUZAT, 2753 West North Avenue, Chicago 47, Ill., Telephone Humbolt 6809-10-11-12
- THE A. P. FOSTER COMPANY, BARRETT BORDER, 11 W. 42nd St., New York 18, N. Y., Telephone PEnnsylvania 6-9133

SPECIALISTS IN BUILDING TRANSFORMERS SINCE 1938

A. P. FOSTER COMPANY

TRANSFORMER ENGINEERS & MANUFACTURERS

719 WYOMING AVENUE, LOCKLAND 15, OHIO (SUBURB OF CINCINNATI)

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MODEL 56
WEBSTER RECORD CHANGER

. . . as new as the Post-War Era

In related industries—names with integrity and reputation go hand in hand. Thus—in radio-phonograph combinations—Webster Record Changer, Model No. 56, will continue in distinguished company—just as its predecessors have in the past. New brilliance of performance has been achieved—new mechanical perfection that will prove most pleasing to dealers and consumers alike. Read the following advantages—then contact us for full details and engineering council.

- ✓ Dependable heavy duty Webster 4 Pole motor—cushion mounted for silent operation. No audible rumble or "wow."
- ✓ Records drop quietly—velvet soft heavy-pile turntable covering.
- ✓ Installation done from top—quick, easy mounting.
- ✓ 14-inch square mounting base. Over-all depth—above and below mounting board—9 inches.
- ✓ Built for lasting performance. Practically no service calls are required.
- ✓ Perfectly crafted—highly styled—beautiful lines.
- ✓ Changes all standard records. Plays ten 12" or twelve 10" records in one loading.
- ✓ Fast change cycle—approximately 4 seconds.
- ✓ Simple, fool-proof operation. Can not be "jammed."
- ✓ Automatic shut-off after last record has played.
- ✓ Feather light needle pressure.
- ✓ Longer life for records—no cracks—no chipped edges.

KEEP UP A GOOD HABIT—BUY VICTORY BONDS

WRITE FOR INFORMATION

WEBSTER CHICAGO

5610 BLOOMINGDALE AVENUE
CHICAGO 39, ILLINOIS

31 YEARS OF CONTINUOUS SUCCESSFUL MANUFACTURE

225

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DOWN TO EARTH!

SAFELY AND QUICKLY

We now have our feet on the ground, and may again pursue our normal peacetime function to immediately utilize all our available facilities. Perhaps, temporarily, we can manufacture all, or part of your product while you redesign and retool a new model.

At the same time we earnestly seek the opportunity to discuss with designers, engineers and manufacturers considering new metal products or wrestling with difficult problems of design, fabrication and assembly, our especial ability to perform all of these functions for you.

If your manufacturing plans hit a bottleneck somewhere along the line, it is probable that consultation with Oiljak may discover a solution that will be mutually profitable.

MACHINING · STAMPING · WELDING · PLATING · PAINTING · ASSEMBLING

The OILJAK MANUFACTURING Co., Inc.

Montclair, N. J.

The Job Complete—from blueprint to finished product

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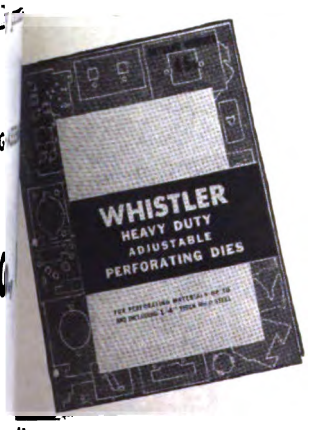
PIERCING 1/4" STEEL

...EASY WITH WHISTLER HEAVY DUTY ADJUSTABLE DIES



Manufacturing costs can be materially reduced and conversion speeded up by putting the "SX" series of heavy duty adjustable perforating dies to work in your plant.

Available from stock in standard sizes and shapes from ⅛" to 1½". Continued reuse in different groupings spreads original costs over a multitude of jobs. Closer centers permit more perforations per press operation. Absolute accuracy on short or long runs. Quick changeover of hole arrangements contributes to greater production from your presses.

If perforating, notching, slitting or rounding dies are used in the manufacture of your products and you are working with materials up to ¼" steel, then good business dictates that you write for the Whistler catalogs and know the time and money saving advantages of Whistler Heavy Duty Adjustable Dies.

S. B. WHISTLER & SONS, INC.
752-756 MILITARY ROAD BUFFALO 17, NEW YORK

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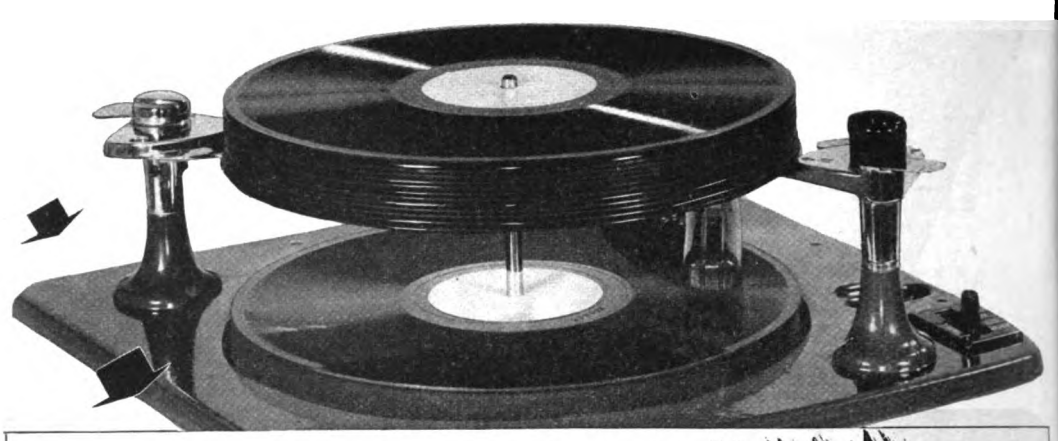

MINIMUM FRICTION
LONG LIFE ♪ SILENT
CONSTANT SPEED

SEEBURG RECORD CHANGERS

The engineering features in SEEBURG RECORD CHANGERS are generally included in high priced professional transcription equipment.

SEEBURG *Wire* RECORDER

The SEEBURG WIRE RECORDER is an electronic engineering achievement! One simple control knob operates the SEEBURG WIRE RECORDER to reproduce and record speeches, plays, meetings, music, radio programs, etc. No needles or discs are used.

IT WILL BE NECESSARY...

for radio manufacturers to make provisions in their circuits to accommodate the SEEBURG WIRE RECORDER. We therefore invite prompt inquiries from interested radio manufacturers.

Seeburg

J. P. SEEBURG CORPORATION · CHICAGO

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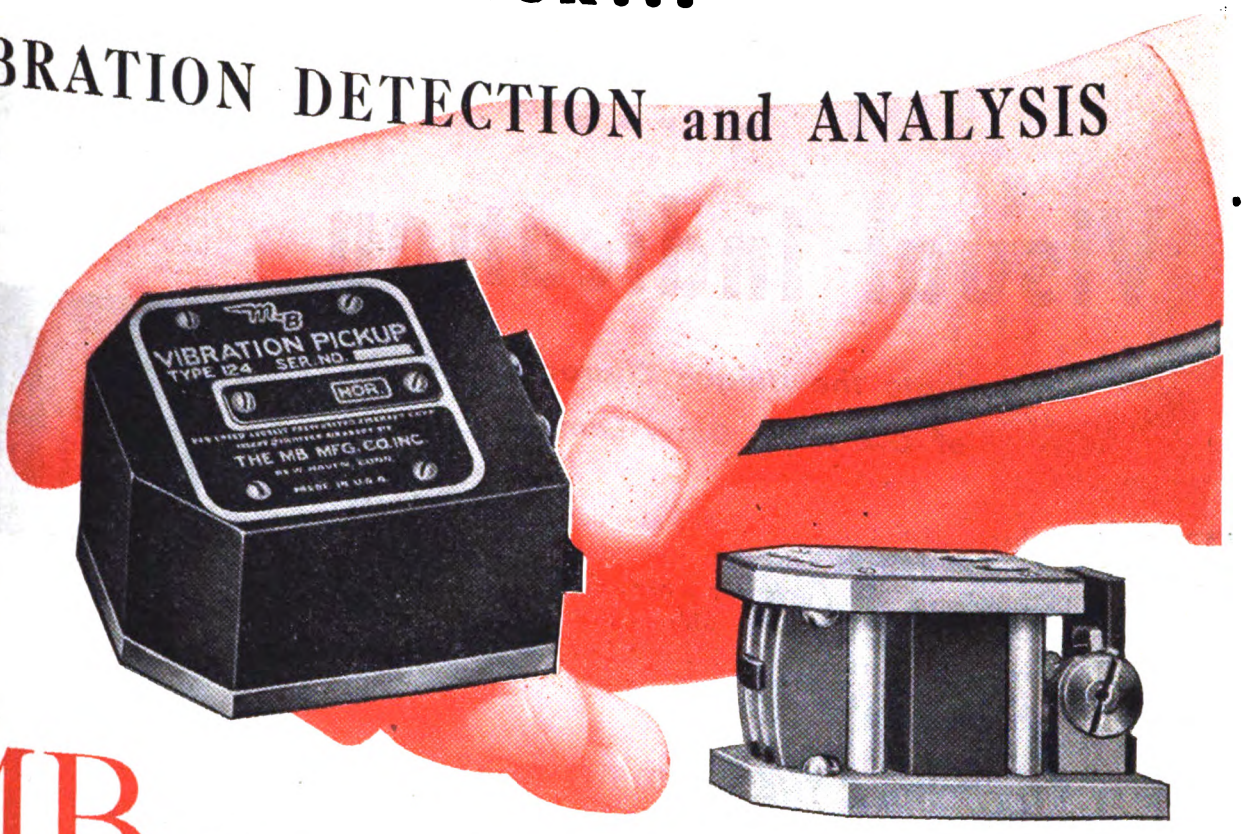
HELPING HAND FOR...

VIBRATION DETECTION and ANALYSIS



MB VIBRATION PICKUP

SENSITIVE TO LOW AMPLITUDE VIBRATIONS, and exceptionally durable under *severe* vibratory conditions, this MB Pickup can be used on a wide range of equipment . . . from small, high-speed rotary motors, to massive, high-powered engines.

It has a high output signal level. With standard equipment, accurate vibratory wave forms can be seen, studied, and recorded.

The MB Pickup is usually operated as a seismic instrument. A lightweight coil, free to move in a powerful magnetic field, generates a voltage proportional to vibratory velocity. Though the complete unit weighs only 8½ ounces, where this weight would influence vibrations, provision can be made for attaching the very light coil directly to the tested structure.

Electrically damped, the MB Pickup maintains its calibration under wide temperature ranges. It can be used in horizontal or vertical planes without affecting the calibration. Adjustment is simple, quick.

Vibration reduction is an essential for product improvement—for extending service life. And the first step is accurate location and diagnosis. You'll find the MB Pickup a big help. Write for 4-page folder. It gives you complete details, specifications.

THE
MB
MANUFACTURING COMPANY, INC.
Vibration Division
1066 State Street, New Haven 11, Conn.

VIBRATION DIVISION

THE MB MANUFACTURING COMPANY, INC.
Vibration Division.
1066 STATE STREET, NEW HAVEN 11, CONN.

Please send descriptive folder on the Vibration Pickup.

Name..... *Position*.....

Company .....

Address .....

VIBRATION ISOLATOR UNITS AND MOUNTINGS • SPECIAL VIBRATION TEST EQUIPMENT

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For Quick Visual Indication

Investigate the Unique Characteristics of G-E Neon Glow Lamps

THE unique characteristics of General Electric Neon Glow Lamps recommend them for a variety of uses in radios and electronic devices . . . as indicators, voltage regulators, pilot lights and test lamps.

The uses described at right are typical. If you think G-E Neon Glow Lamps can be useful to you, write or phone the address below. Experienced General Electric Lamp Engineers will be glad to discuss your problems with you.

NE-51 For general indication, such as showing existence of potential across various parts of electrical circuits.

NE-17 Indicator and pilot light lamp that flashes to show condition of B-battery in portable radios. Frequency of flashes decreases as battery runs down.

NE-48 (also N-E 16). Indicator lamps. Special volt-ampere characteristics of these lamps indicate use as voltage regulators. Screw base lamp available as NE-45.*

*NE-16 meets JAN-1A specifications for 991. Special marking JCG-991 supplied for small extra charge.

CONSIDER THESE ADVANTAGES

1. **Distinctive orange-red glow — no colored cover glass needed.**
2. **Dependable performance and long life — rated at 3,000 hours.**
3. **Very low current consumption — less than ½ milliampere for smallest lamp.**
4. **Variety of sizes and wattages.**
5. **High resistance to vibration, shock.**
6. **Normally usable on a-c or d-c.**
7. **Screw base lamps for 105-125 v. circuits; similar lamps available with bayonet bases, but external resistance required.**
8. **Produce practically no heat.**
9. **Nearly flat volt-ampere characteristics.**
10. **Insensitive to voltage variations above critical value.**

ORDER NO.	NE-2	NE-51	NE-17	NE-48	NE-16 ④	NE-45	NE-30	NE-32	NE-34	NE-36	NE-40	NE-42
Watts, Nominal	1/25	1/25	③	¼	¼	¼	1	1	2	2	3	3
Volts (Circuit)	105-125	105-125	③	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Starting Voltage ① AC	65	65	③	65	—	65	60	60	60	60	60	60
Starting Voltage ① DC	90	90		90	⑤	90	85	85	85	85	85	85
Base	★Unbased (Wire Terminals)	★S. C. Bay. Min.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	Cand. Screw	Medium Screw	★D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.
Maximum Overall Length	② 1 1/16"	1 3/16"	1½"	1½"	1½"	1⅜"	2 1/16"	2"	3 5/16"	3¾"	3 5/16"	3¾"
List Price (plus tax)	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

① Applies to lamp when new.
② Glass part; wire terminals extend additional 13/16",
③ Designed for DC flashing operation in RC circuit.
④ Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
⑤ Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).
★ All Bayonet Base Lamps Need External Resistance.

For further information, write address below for Bulletin 7100

NELA SPECIALTY DIVISION, LAMP DEPARTMENT

GENERAL ELECTRIC

1 Newark Street, Hoboken, N. J.

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VICTORY OVER VIBRATION

IN COMMUNICATIONS

AIR — LAND — SEA

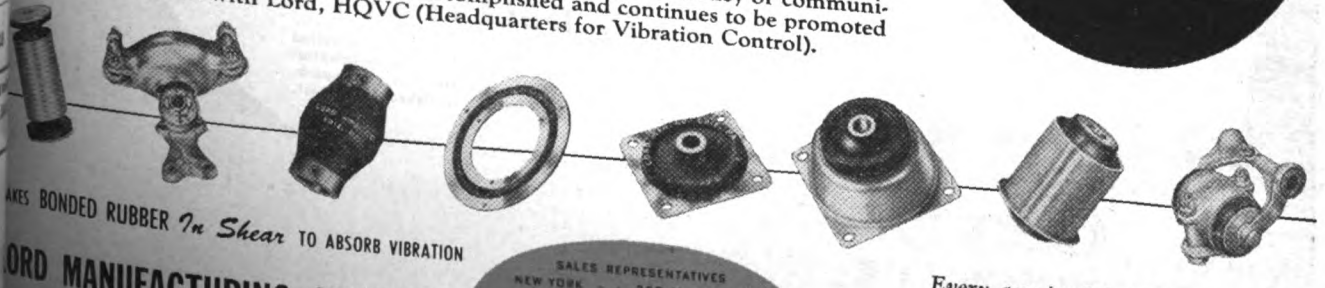
...io, electronic and radar equipment is necessarily delicate in construction and neces-
...y precise in its functioning. The enormous recent advances, first made on paper,
...n translated into practice have almost invariably run into one major difficulty . . .
...ational interference.

So, Lord, pioneer and leader in subduing the harmful forces of vibration, has been
...ed upon for a wide range of applications in this field. Where possible, outside vibra-
... forces have been isolated at their source; vibration of component parts has been
...trolled; and delicate parts and instruments have been protected from outside inter-
...nce by isolation.

Lord engineers, the most experienced in the field of vibration, have access to the
...test file of experimental data and case studies of practical experience in existence, and
...y have the largest assortment of mountings, all of exclusive Shear Type Bonded Rubber
every one engineered for the specific conditions it has to meet.

The safety of passengers in the air, on land and sea; the pleasure of large audiences;
enjoyment of radio and television at home; all depend on the efficiency of communi-
on systems, an efficiency which has been accomplished and continues to be promoted
constant consultation with Lord, HQVC (Headquarters for Vibration Control).

LORD
SHEAR TYPE
Bonded Rubber
MOUNTINGS



...AKES BONDED RUBBER *In Shear* TO ABSORB VIBRATION

...ORD MANUFACTURING COMPANY
ERIE, PENNSYLVANIA

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TORONTO, CANADA

Originators of Shear Type Bonded Rubber Mountings

Every genuine Lord Mounting carries the name "LORD" embossed in the rubber or in raised letters on the forgings.

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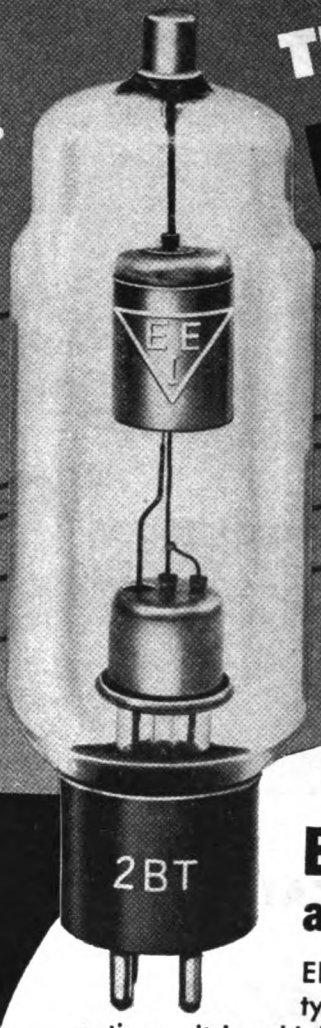
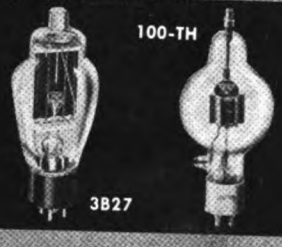
It's here!

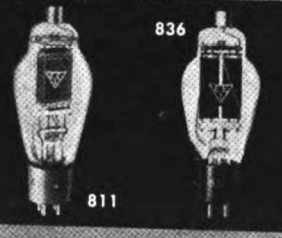
The new

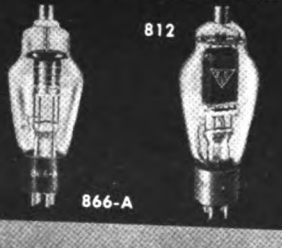
E·E TELEVISION RECTIFIER



A HIGH VACUUM TUBE WITH PEAK INVERSE VOLTAGE RATING OF 40KV. AVERAGE ANODE CURRENT 5 M.A.







E·E TYPE 2BT available now!

EE 2BT closes the gap in rectifier types suitable for television applications. It is a high vacuum type having high peak inverse rating, and expressly designed for plate supply in video receivers requiring potentials to 12,700 volts on the projector tube.

By incorporating the EE 2BT in television designs, engineers can now eliminate flashback trouble without specifying a rectifier with ratings considerably in excess of actual requirements. For complete specifications and for other important details that explain why the EE 2BT offers exceptional advantages to designers write today.

FAST DELIVERY!

The popular types (illustrated at left) are now supplied from stock. Write for data book, a thirty page compilation of electronic tube types, characteristics and operational information will be promptly furnished on request.

ELECTRONIC ENTERPRISES, INC.

ELECTRONIC e ENTERPRISES

GENERAL OFFICES: 65-67 SEVENTH AVENUE, NEWARK, 4, N. J.
EXPORT DIVISION: 25 WARREN STREET, NEW YORK, 7, NEW YORK
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MITCHELL-RAND offers . . .

6 different brands of *Varnished Tubing*

. . . TO COVER EVERY KNOWN REQUIREMENT

Standard

Double Saturated

Triple Strength

Impregnated

Hygrade

Mirac

FIBREGLAS (INORGANIC) VARNISHED TUBINGS

M-R Fibreglas Varnished Tubings are made in four grades; Standard; Double Saturated; Triple Strength and Impregnated.

STANDARD GRADE has maximum flexibility, is treated with a minimum of varnish and recommended for high temperatures where dielectric strength is not a factor.

DOUBLE SATURATED has all qualities of the Standard Grade but with additional coats of varnish to bring the dielectric rating up to 1500 volts.

TRIPLE STRENGTH is built up with coats of especially flexible insulation varnish for dielectric ratings up to 3,000 volts and is particularly suited where assembly operations include the possibility of rough handling.

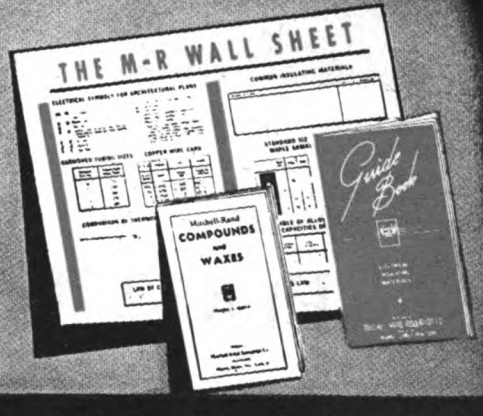
IMPREGNATED is the Optimum in Superiority for high gloss, non-hydroscopic, resistance to high temperatures, oils, acids, etc. IMPREGNATED has a dielectric rating beyond 8,000 volts and is unequalled for Long Life Under Most Severe Conditions. Write For Samples.

FOR USERS OF COTTON YARN VARNISHED TUBINGS

The Mitchell-Rand MIRAC and HYGRADE Varnished Tubings of long staple fibre yarn are comparable to Fibreglas Tubings in dielectric ratings, tensile strength, flexibility and long life. Write For Samples.

FREE FOR THE ASKING

Write today for your free copy of the M-R WALL CHART with its engineering tables, electrical symbols, carrying capacities of conductors, dielectric averages, thicknesses of insulating materials, tubing sizes, tap drill sizes, etc.



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for 56 YEARS
THE ELECTRICAL INSULATION HEADQUARTERS
EST. 1889

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Insulating Papers and Twines
Cable Filling and Pothead Compounds
Friction Tape and Splice
Transformer Compounds
Fiberglas Saturated Sleeving, Varnished Tubing
Asbestos Sleeving and Tape
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth, Tubing
Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevings
Impregnated Varnish Tubing
Insulating Varnishes of all types
Extruded Plastic Tubing

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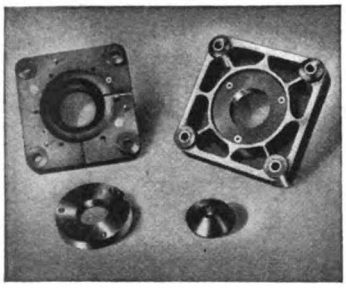
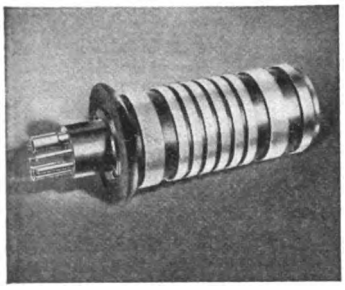
POSSIBILITIES IN PLASTICS





Above are examples of engineered plastics, produced by us for military requirements. Their design and production involved molding techniques that can be applied advantageously to many consumer products.

Familiar uses of plastics are being served again. Most significant, in suggesting the larger potential usefulness of molded plastics, will be their successful utilization in applications where other materials have been used by custom or tradition.

During the war years, plastics had to justify selection thru superior performance under field conditions. Molding experience and techniques developed and improved during that period are now available to you thru this organization.

If you seek product betterment, let us help you examine the possibilities in plastics. We have the most improved equipment for injection, transfer and compression molding. Our production is varied, from simple molded parts, produced in volume on high speed injection presses, to complex assemblies, transfer-molded with metal inserts. Our experience and complete facilities—from design to assembly—may benefit you. Get in touch with us. For information on our services, ask for Folder File E-12.

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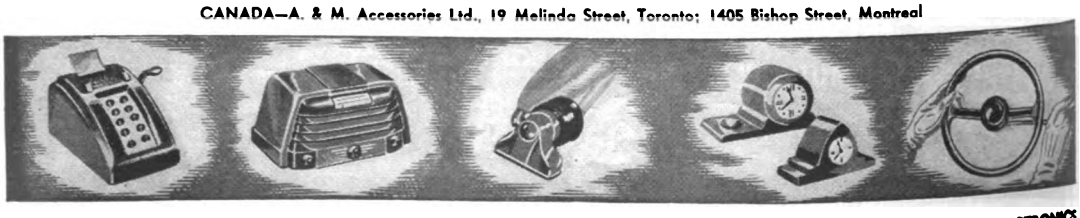

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MEASURE YOUR HIGH VACUUMS WITH THIS REVOLUTIONARY NEW...

KNUDSEN GAUGE

HERE ARE THE NEW, PRACTICAL FEATURES:

1 No special mountings or rigid supports required . . . easy to transport . . . easy to install.

2 Direct continuous-readings save time and labor. Its operation does not require a skilled technician.

3 Low temperature heaters . . . nothing to burn out . . . nothing can be damaged by atmospheric exposure.

THIS fine instrument is recommended for *every* vacuum installation where pressures of less than one micron are maintained. For full details on the Knudsen Gauge, high-vacuum equipment, installation or service, write—
High Vacuum Headquarters

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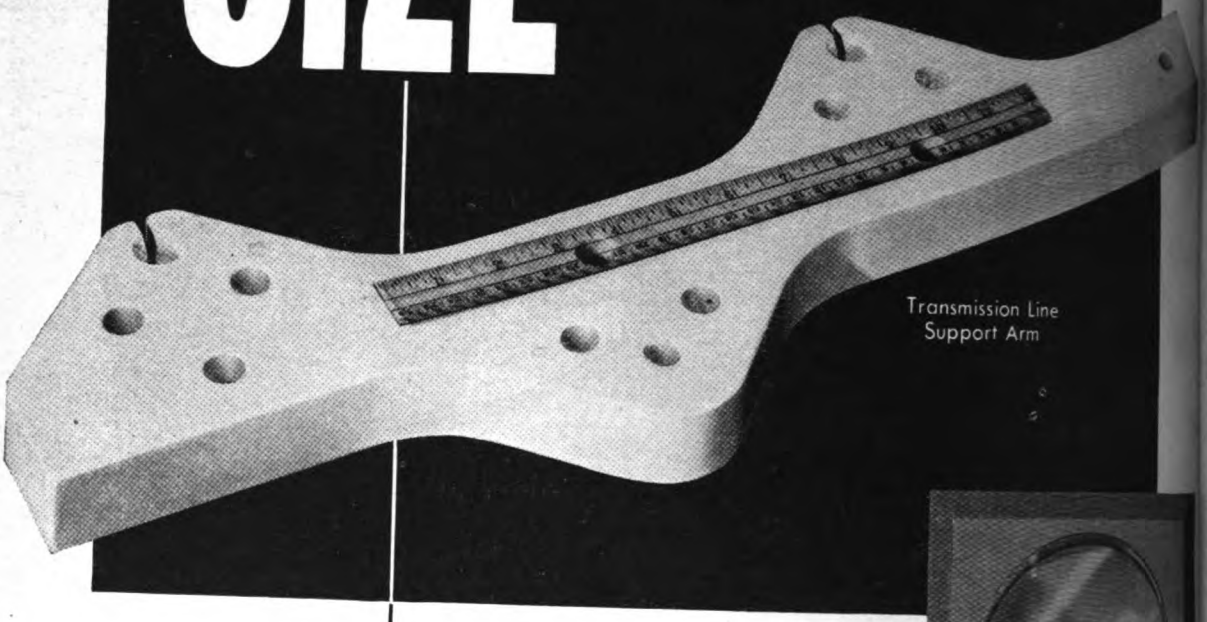
SIZE DOESN'T MATTER



Transmission Line Support Arm

Radio Tube Cathode-Heater Insulator

. . . to STUPAKOFF

LARGE or small, simple or complicated, if the need is for the proper ceramic insulators the place to get them is Stupakoff. Two generations of experience, engineering knowledge, continuous laboratory research, and that intangible but most valuable asset—ingenuity, are concentrated on the solution of every insulation problem which comes to Stupakoff.

Precision in the final product is assured through absolute control over every procedure-from selection of raw materials to final packing.

Quality comes first with Stupakoff, but is closely followed by efficiency which is extended to every known economy obtainable through the use of up-to-date equipment, specialized trained workers, and modern volume production methods.

Stupakoff takes pride in its ability to produce the finest, most intricate precision ceramics obtainable. The toughest ceramic problem you can pose is a challenge to Stupakoff engineers, and they never refuse a challenge.

Consultation entails no obligation. Write, wire or phone us.

★ BUY VICTORY BONDS ★

ARMY (E) NAVY "FOR GREAT ACHIEVEMENT"

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

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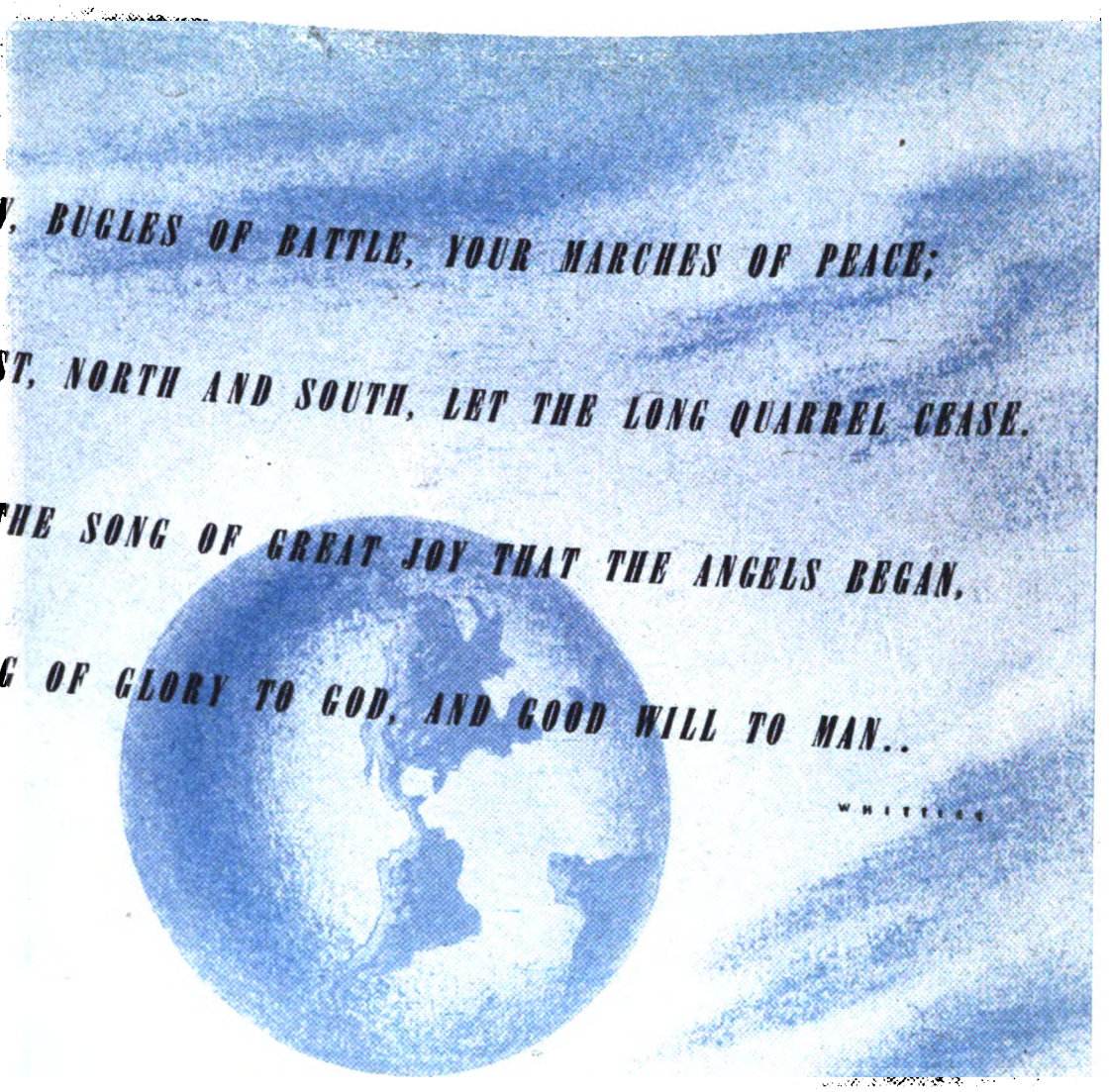

As the tumult and the shouting die . . . and the Yuletide bells ring out their old, old story of peace on earth . . it is good to make merry and wish our fellowmen all over the world . . . Merry Christmas and a Grand New Year . .

GENERAL INSTRUMENT CORPORATION

829 NEWARK AVENUE • ELIZABETH 3, N. J.

VARIABLE CONDENSERS • TUNING MECHANISMS • RECORD CHANGERS • SPEAKERS • OTHER RADIO COMPONENTS

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Products for the World of Electronics

EXPORT DEPARTMENT — 13 EAST 40th ST., N[illegible]RK, N. Y.— Cable Address ARLAB — All Codes

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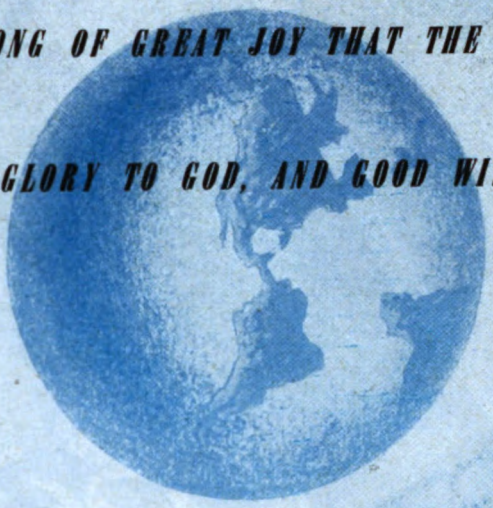
BLOW, BUGLES OF BATTLE, YOUR MARCHES OF PEACE;

EAST, WEST, NORTH AND SOUTH, LET THE LONG QUARREL CEASE.

SING THE SONG OF GREAT JOY THAT THE ANGELS BEGAN,

SONG OF GLORY TO GOD, AND GOOD WILL TO MAN..

WHITTIER



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VARIABLE CONDENSERS · TUNING MECHANISMS · RECORD CHANGERS · SPEAKERS · OTHER RADIO COMPONENTS

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CATHODE-RAY TUBES

Better than ever

➡ Whether for television, for oscilloscopes, or other uses, Ken-Rad Cathode-Ray Tubes are unsurpassed in clearness of image and other qualities born of advanced design . . . Now important new Ken-Rad facilities promise still better, more reliable performance, further aiding manufacturers who feature these fine tubes in their equipment.

● *Write for your copy of "Essential Characteristics" the most complete digest of tube information available.*

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DIVISION OF GENERAL ELECTRIC COMPANY

OWENSBORO, KENTUCKY

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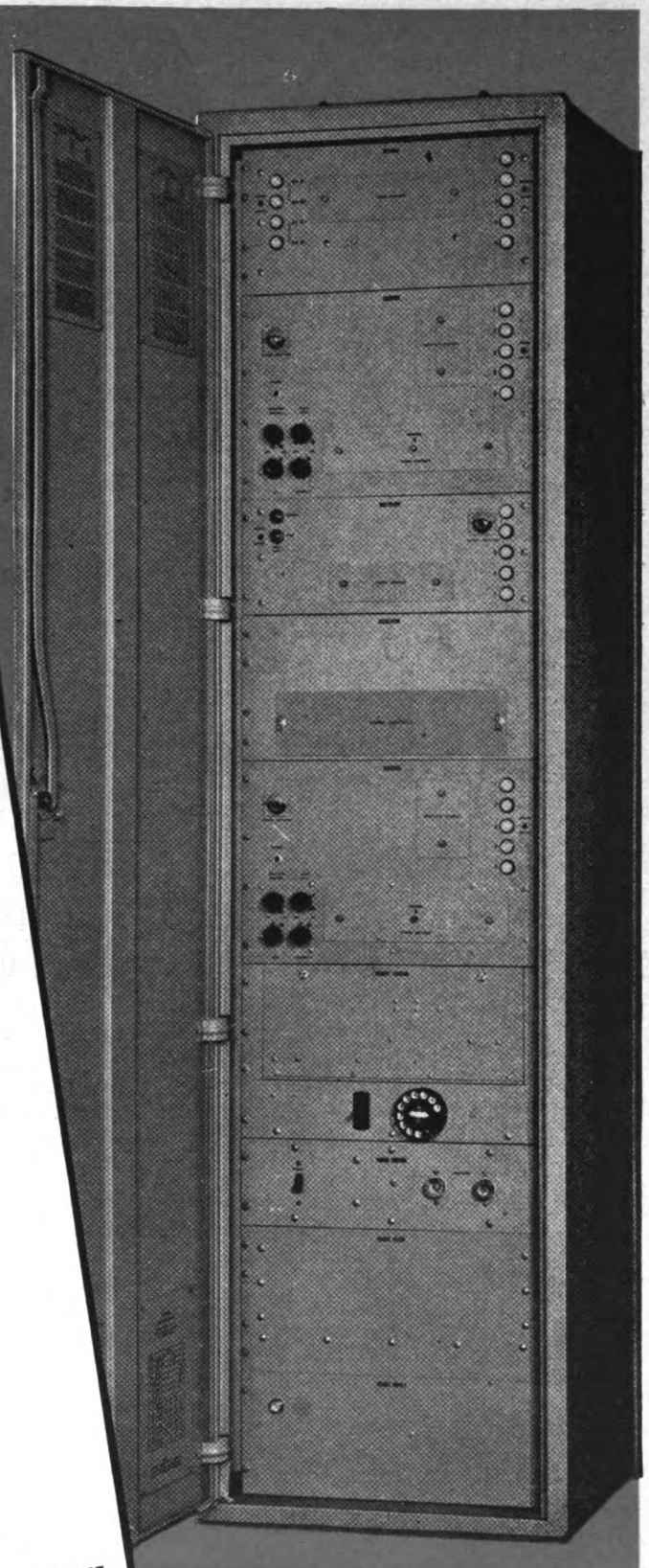
DUAL DIVERSITY RECEIVERS



by PRESS WIRELESS

- Two identical superheterodyne receivers with isolating antenna matching network
- Five pre-tuned bands 2.4-23 megacycles
- Common crystal or self-excited HFO and BFO in thermostatically controlled oven
- Interlocking diversity AVC action
- Four diversity antenna combinations
- Electronic "eye" tuning indication
- Local and remote dial control
- Self contained power supply
- Cabinet rack and 19" panel construction

ENGINEERING BULLETIN SENT ON REQUEST

DUAL DIVERSITY RECEIVER
Press Wireless Model 6019A

PRESS WIRELESS, INC.

Executive and Sales Office, **1475 BROADWAY, NEW YORK 18**

ARMY NAVY

Awarded to our Hicksville, L. I. plant for outstanding achievement in war production.

PARIS · BUENOS AIRES · RIO DE JANIERO · MONTEVIDEO · MANILA · BERNE · SANTIAGO DE CHILE · NEW YORK · SHANGHAI · LOS ANGELES · LONDON · HAVANA

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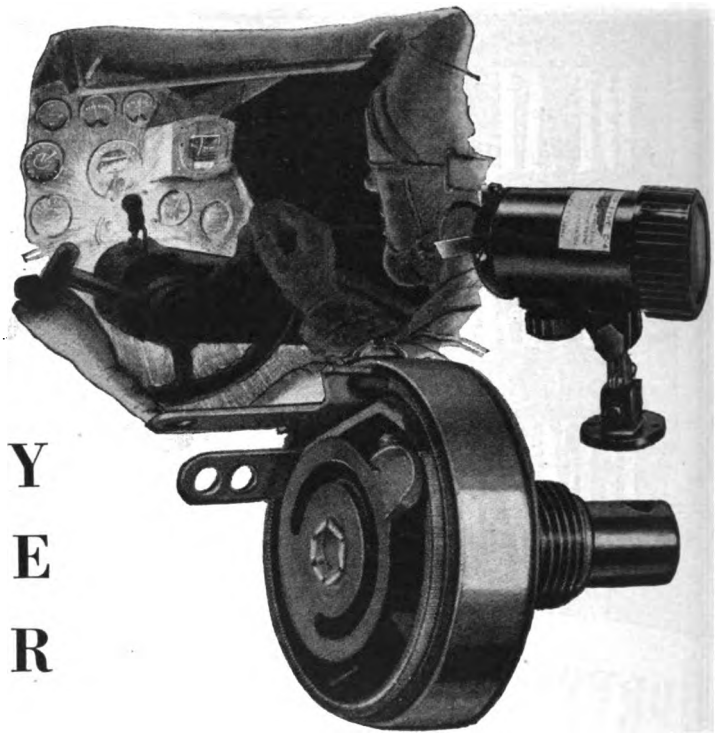
Controlled Brilliance... Thanks to a MALLORY VARIABLE RESISTOR



CONTROLLING the brilliance of this small cockpit lamp, made by Standard Aircraft Products, Dayton, Ohio, is a variable wire wound Mallory Resistor.

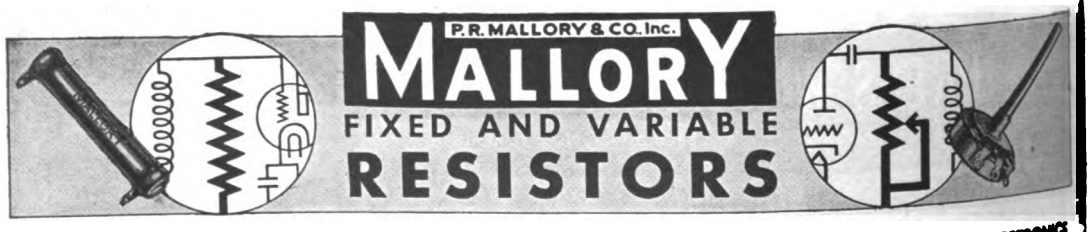
This lamp, used as an auxiliary light to illuminate the instrument panel or any area in the cockpit, is only 1¾" in diameter and 5 1/16" long. To control it, a standard Mallory Resistor of the C type was selected because of its compact size and precision construction . . . rugged enough to operate efficiently even when subjected to extreme vibration. In this application, a 50 ohm unit is being used for 12 volt operation, and a 200 ohm unit for 24 volt operation.

Standard C type Mallory Variable Resistors are available from 6 to 15,000 ohms at 2 watts. Other Mallory variable resistors are available in ratings from 2 to 9 watts, and from 0.5 to 150,000 ohms resistance in single and multiple units. Variable carbon resistors range from 5000 ohms to 9 megohms. Fixed and adjustable wire wound resistors are manufactured in a broad range of resistances, rated from 10 to 200 watts.

Complete details covering resistors, capacitors, switches, power supplies and other standard precision electronic parts are in the Mallory catalog. Ask your nearest Mallory Distributor for a copy, or write us today.

Make it a policy to consult Mallory for engineering assistance while your designs are still in the blueprint stage.

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA



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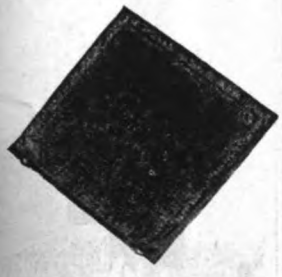


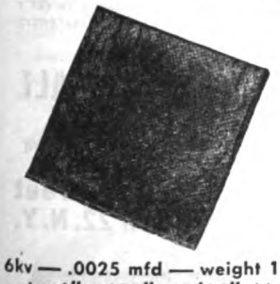
6kv — .5 mfd — weight 27 oz.
size 6" x 6" x ½" thick.

8kv — .03 mfd — weight 19 oz.
size 6" x 6" x 7/16" thick.

8kv — .012 mfd — weight 6 oz.
size 6" x 3" x ¼" thick.

3kv — .0028 mfd — weight .5 oz.
size 3" x 2" x 1/16" thick.

3½kv — .00167 mfd — weight .4 oz.
size 3" x 1" x 1/16" thick.



6kv — .0025 mfd — weight 1 oz.
size 6" x 1½" x 1/16" thick.

15kv — .0022 mfd — weight 1.5 oz.
size 2-11/16" x 1-⅞" x 7/32" thick.

AMP

HIGH-VOLTAGE CAPACITORS
FOR RADAR AND SIMILAR APPLICATIONS

The new AMP high-strength dielectric, and a special fabrication technique give AMP Capacitors these outstanding advantages:

Approximately 25% lighter in weight; approximately 25% smaller —

AMP Capacitors are smaller and lighter than any other type of high-voltage capacitors of equal capacity and voltage. High dielectric strength refractory film plus special molded and bonded construction reduce size and weight and eliminate necessity of usual can and oil filler.

A 15 kv., 0.0022 mfd. unit measures only 2-11/16" x 1-7/8" x 7/32" and weighs only 1.5 oz.

Minimum losses —

Complete molding and bonding of unit protects against edge breakdown and corona.

Peak performance at high temperatures —

AMP Capacitors operate effectively at higher temperatures than ordinary capacitors. Minimum capacitance drift — less than 0.015% per degree C. over a range of — 60° to + 100° C.

High voltage operation —

Dielectric sheets are homogeneous, and not limited to size, permitting use of very high voltage stresses per mil without corona. High voltage units can be made in one piece instead of usual assembled sections.

AMP High Voltage Capacitors are made to specification. Send specific information concerning your application. A careful analysis of your requirements will be submitted by our engineers.

AMP

AIRCRAFT-MARINE PRODUCTS INC.
1521-53 NORTH FOURTH ST., HARRISBURG, PENNA.

In Canada: DAVID C. ORROCK, 1405 Bishop St., Montreal, Que.
F. N. ADAMS, 726 Homer Street, Vancouver, B. C.
F. MANLEY CO., 43 Victoria Street, Toronto, Ont.

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SELENIUM

B-L METALLIC RECTIFIERS

COPPER SULPHIDE

offer you these advantages:

They are COMPACT — SILENT — DEPENDABLE TROUBLE-FREE — RUGGED — and

They are ADAPTABLE for power outputs from Milliwatts to Kilowatts.

Many rectifier applications, heretofore considered impractical, have been devised by B-L Engineers. It is more than likely that they can be of assistance in solving your problems of converting AC current to DC... Write for Bulletin R38-a.

THE BENWOOD-LINZE COMPANY

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DESIGNED FOR DISCRIMINATING MANUFACTURERS

Leakproof

ENAMELED MAGNET WIRE

A product, resulting from many years of research in the field of fine wire manufacture, that meets the most rigid requirements of radio and ignition coils. A new coating method gives a smooth, permanently-adherent enameling, and mercury-process tests guarantee perfect uniformity. Great flexibility and tensile strength assure perfect laying, even at high winding speeds. If you want reduction in coil dimensions without sacrificing electrical values, or seek a uniform, leakproof wire that will deliver extra years of service, this Hudson Wire product is the answer.

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SERVICE

Also manufacturers of high grade cotton and silk covered wires, cotton and silk coverings over enamel coated wires, and all constructions of Litz wires. A variety of coverings made to customers' specifications, or to requirements determined by our engineers. Complete design and engineering facilities are at your disposal; details and quotations on request.

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HUDSON WIRE CO.

Division

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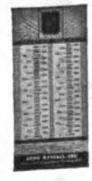
for the hard-to-do

When the assembly of your product requires a special fastener or cold-forged product, call on our consultant service to help you at no obligation to you. We are equipped to manufacture cold-forged specialties in a wide range of metals, sizes and designs, in large or small quantities. In most instances, too, you'll find that cold-forging your special part represents a saving.



This Decimal Equivalents wall chart is accurate to four places and signalled in three colors. Yours at no cost or obligation. Just send us your name, title and address.

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SPECIAL NAILS RIVETS SCREWS

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turbo INSULATIONS

..keyed to every installation need!

Electronic communication circuits are a proving ground for electrical insulation. The varied conditions imposed—high voltage, heat, climatic exposure, battery acid, fumes, etc.—make several insulations, each with specific characteristics, essential. To meet these diversified requirements, TURBO engineers have developed four types of sleevings that assure unfailing operation under any given operating condition. Each is supplied in a full range of colors and sizes that speed installation and simplify maintenance.

FLEXIBLE VARNISHED OIL TUBING: offers immunity to corrosive fumes, acid, alkalis and most solvents, with enduringly high dielectric values. It is impervious to moisture and non-hygroscopic.

VARNISHED GLASS TUBING: capable of functioning in high ambient temperatures—enclosed motors, unventilated areas, and general heavy duty installations.

WIRE IDENTIFICATION MARKERS: two types—sleeve type that slips directly over pipes, tubes, conductors; and tab type with flexible flag attached to sleeve. Both available in any marking.

Write today for free Specimen Board with samples and sizes of each.

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PLASTIC

PRODUCTS

★ Here at Rogan, you are invited to avail yourselves of our complete knowledge and long experience in all phases of plastic molding. Our staff of trained experts will be glad to assist you with your plastic problems, no matter how involved or comprehensive.

In addition to compression molding, we also offer an exclusive "deep relief" branding process that goes a long way toward reducing the cost of plastics that must bear markings, lettering or other descriptive matter.

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Compression Molders and Branders of Plastics

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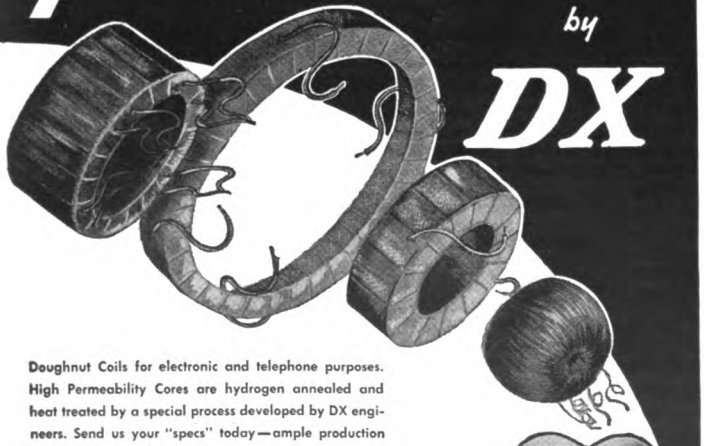

Doughnut Coils for electronic and telephone purposes. High Permeability Cores are hydrogen annealed and heat treated by a special process developed by DX engineers. Send us your "specs" today—ample production facilities for immediate delivery.

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GENERAL OFFICES 1200 N. CLAREMONT AVE., CHICAGO 22, ILL., U.S.A.

DX COILS "the heart of a good receiver"

RAILWAY EXPRESS AGENCY

A Better *Service*

Born of Our

Wartime Experience

With the nation engaged in all-out war, transportation became a factor of dominating importance. Every form of shipping was summoned into action. Railway Express, equipped to deliver nationwide service in peacetime, was suddenly called upon to use its complete resources in equipment and organization to cope with the most pressing demands in history. During the first six months of 1945, the Government express traffic was 42 times heavier than for the entire year of 1939.

Gun, Tank and Engine Parts, Serums and Drugs... Urgent and strategic material had to move speedily and accurately, and in tremendous volume. At the same time the fast and uninterrupted flow of raw materials and finished products to and from manufacturing plants was a wartime essential.

Camp and Base Express Offices ... The personal package traffic between homes and camps meant millions of shipments daily. Fully equipped Express offices handled this important feature of wartime service.

Blood Units ... High speed handling and special refrigerator containers saved thousands of American wounded. Over 8 million pints of blood were shipped in this manner by Express.

Ration Books and Tokens... More than 2½ million pounds of ration books, and ration tokens by the billions were delivered to their destinations through 23,000 Express offices.

War Dogs for the K-9 Corps... The highly technical service of handling and shipping the nation's war dogs was assigned solely to Railway Express, and performed with signal success.

The above is a partial summary of wartime Express service. Today, with the return of peace, we are adding to our facilities all of the lessons learned in that historic period. We appreciate your cooperation and tolerance during the wartime days. We promise, in the not too distant future, a service superior to any we have rendered during our long nation-wide record.

[redacted] AGENCY, Inc.

NATION-WIDE RAIL-AIR SERVICE

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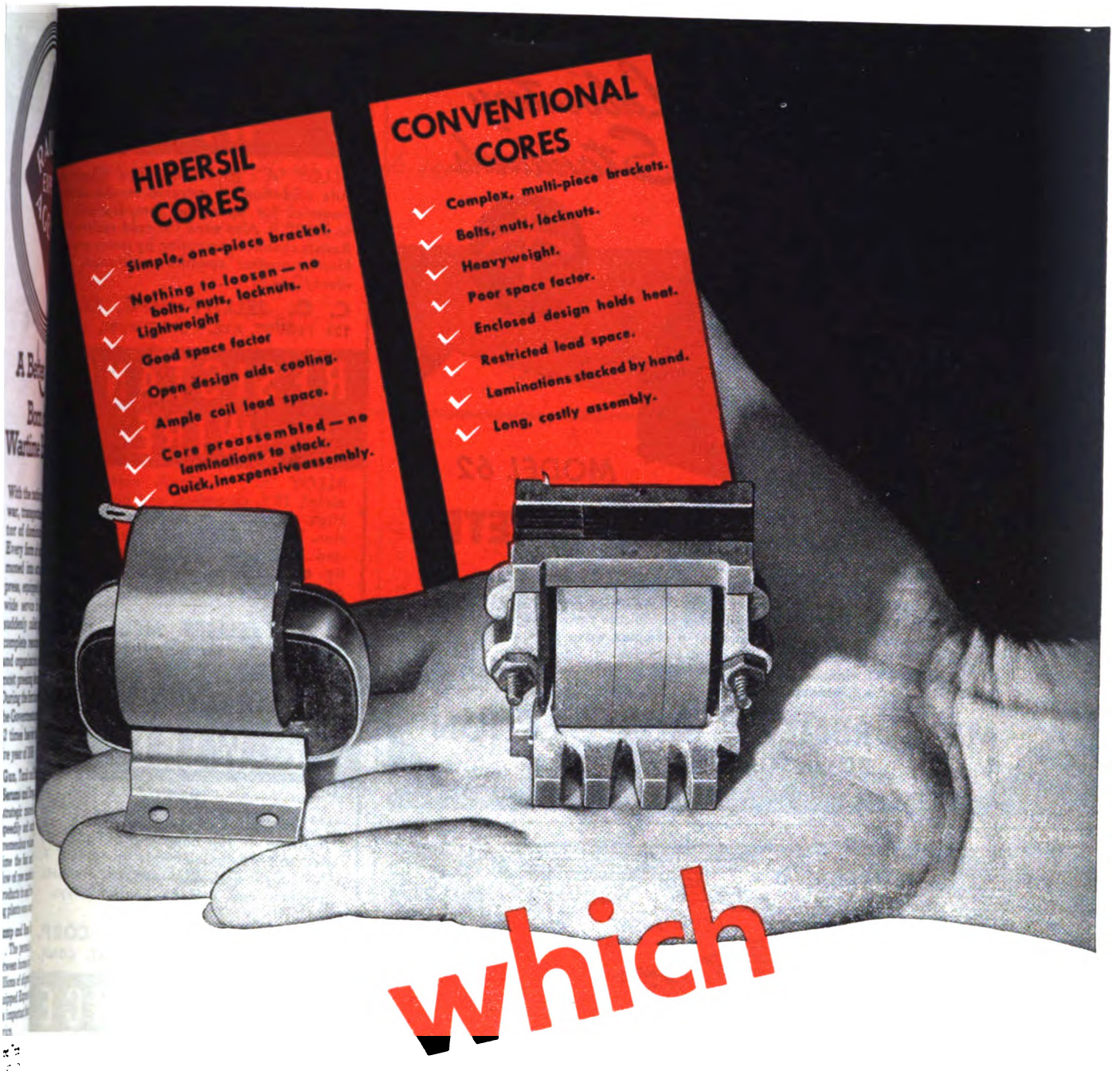

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is a better answer to communications requirements?

Which offers the most advantages in your present—or future—applications?

If space . . . weight . . . ease and cost of assembly . . . are factors at all, the answer is plain: HIPERSIL Cores can make a tremendous difference in simplifying manufacture, as well as in providing important improvements in performance.

HIPERSIL—the high-permeability silicon steel with ⅓ greater flux-carrying capacity—opens up new possibilities in electronic transformer design and manufacture. Full data on HIPERSIL characteristics and the advantages of Type "C" Cores may suggest new and better answers to your problems. Contact your Westinghouse representative or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa. J-70466

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AVAILABLE FOR PROMPT DELIVERY

Hipersil Type "C" Cores are available for prompt delivery in a complete range of sizes, as required, and in five lamination thicknesses: 29 gauge, 5 mil, 3 mil, 2 mil and 1 mil.

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Laboratory Standards

MODEL 62

VACUUM TUBE VOLTMETER

SPECIFICATIONS:

RANGE: Push button selection of five ranges—1, 3, 10, 30 and 100 volts a. c. or d.c.
ACCURACY: 2% of full scale. Useable from 50 cycles to 150 megacycles.
INDICATION: Linear for d. c. and calibrated to indicate r.m.s. values of a sine-wave or 71% of the peak value of a complex wave on a. c.
POWER SUPPLY: 115 volts, 40-60 cycles—no batteries.
DIMENSIONS: 4¾" wide, 6" high, and 8½" deep. **WEIGHT:** Approximately 6 lbs.
PRICE: $135.00 f.o.b. Boonton, N. J. Immediate Delivery

MEASUREMENTS CORPORATION
BOONTON, NEW JERSEY

Yes, Extra Value!

Long after the ordinary pivot has worn out you'll find PERMO-PIVOTS in the prime of life—faithfully keeping precision instruments precise! It's all due to the special PERMOMETAL tip—the ideal osmium alloy. . . . Made to your specifications.

Write for information!

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MANUFACTURING METALLURGISTS

RESISTANCE WIRE

ALLOY "A": Nickel-chromium alloy, resists oxidation at extreme temperatures. Essential for operating temperatures up to 2100° F. Also used for cold resistance. Resists chemical corrosion by many media. Non-magnetic; specific resistance, 650 ohms/C.M.F.

C. O. JELLIFF MFG. CORP.
123 PEQUOT AVE. • SOUTHPORT, CONN.

RESISTANCE WIRE

ALLOY "C": Nominally contains 60% nickel, 15% chromium, and balance iron. High resistance to oxidation and corrosion. Widely used in resistances for radio and electronics, industrial, and domestic equipment. Operating temperature up to 1700° F. Specific resistance 675 ohms/C.M.F.

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ALLOY "180": Nickel-copper alloy with resistivity of 180 ohms/C. M. F. Widely used for resistor elements up to 750° F. (400° C). For radio controls, magnets, rheostats and voltage control relays.

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RESISTANCE WIRE

ALLOY "45": Alloy of 55% copper, 45% nickel with a constant electrical resistance over wide range of temperatures. Specific resistance 294 ohms/C.M.F.; temperature coefficient 0.00002 ohms per degree F; 32 to 212 degrees range. Used in winding of precision resistors.

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RESISTANCE WIRE

KANTHAL: Exclusive manufacturers of KANTHAL, an outstanding achievement in resistance-wire development. Now available—complete data upon request.

C. O. JELLIFF MFG. CORP.
123 PEQUOT AVE. • SOUTHPORT, CONN.

Note: All alloys are produced in high-frequency type furnaces, and are furnished bright, dull or oxidized finish, also with enamel, silk, or cotton insulation.

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you can get to work with plastics

NOW

here's

HOW

Here's a new Dow plastic that gives you the rare opportunity to put your plastic plans to work—*RIGHT NOW!* Most plastics are still short. But this new Dow development—its durability and effectiveness proved in war—is now freely available for the many peacetime jobs that call for its unique qualities. It may be just the thing you need. Suggested applications include tools, electrical insulation, home appliances, sporting goods. Field experience and Dow research point unmistakably to a world of opportunities for new and profitable civilian applications. Full data is waiting for you. Push your plastic program—*NOW*—ask Dow about Styraloy at once!

STYRALOY

SOMETHING REALLY DIFFERENT IN PLASTICS
For better insulation, tool handles, and products as varied as scuff plates, floor mats and fittings or gaskets, Styraloy is the answer to tough service demands.

CHECK THESE PROPERTIES
High dielectric strength, low power loss; flexible and shock resistant from −90° to 212° F.; light weight; negligible water absorption; resists heat, many chemicals, permanent indentation and abrasion; easily machined.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN
New York • Boston • Philadelphia • Washington • Cleveland • Detroit • Chicago
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DOW
PLASTICS
STYRON • STYRALOY • ETHOCEL
ETHOCEL SHEETING • SARAN • SARAN FILM

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. . . 15 CUBIC FEET A MINUTE

The No. 1½* is one of many blowers manufactured by the L-R Mfg. Div. with C.F.M's at 8000 R.P.M. ranging from 15 to 270. They will outperform many larger types and where size and weight are factors, they solve cooling problems presented by electronic tubes or circuit components in airborne communication units as well as in many industrial applications.

*WEIGHT: 2 oz.; CAPACITY: 15 C. F. M. at 8000 R.P.M.; CONSTRUCTION: Housing of high impact phenolic plastic. Wheel is turbotype cadmium-plated steel; SIZE: 2⅝" long x 61/64" wide x 2½" high.

L-R MANUFACTURING DIVISION OF

The RIPLEY Company

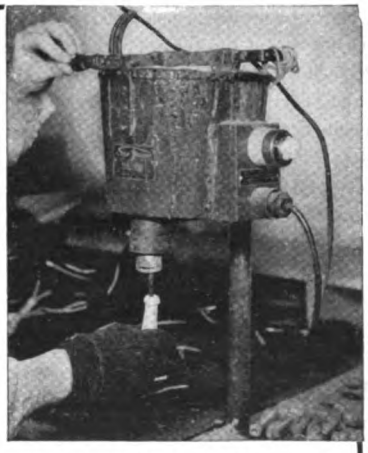
13 NEW LITCHFIELD STREET TORRINGTON, CONNECTICUT

FOR DISPENSING MELTED COMPOUNDS . . .

This veteran Sta-Warm CN dispensing pot symbolizes thousands similar to it which have operated "for years without adjustment or failure."

All Sta-Warm electrically heated tanks, kettles and pots are built to rigid specifications which insure uninterrupted production regardless of the compound being melted.

Many feet (sometimes a mile) of resistance wire constitute the heating element in Sta-Warm tanks. This heating element, in a wide variety of circuits, blankets sidewalls and bottom of each tank or pot to give widest distribution of heat at black heat temperatures, thereby resulting in low wattage per square inch of tank surface and aiding the long useful life of the heater. Dependable thermostats assure maintenance of proper temperature having practical variation of plus or minus 5° F. Heating, melting or dispensing of compounds will be a problem to you no longer . . . if you specify "Sta-Warm." Why not inquire today for new bulletin 038W?



Of this 1 gal. Sta-Warm CN dispensing pot, the Kellogg Brush Mfg. Co. says "Your dispensing pots have operated in our plant for years without adjustment or failure." Pot is here seen loading brush handle with thermal chemical compound before inserting brush frame.

STA-WARM ELECTRIC CO.
1000 N. CHESTNUT ST. • RAVENNA, OHIO

WIRE SO FINE IT MUST BE *Magnified* TO BE SEEN

WOLLASTON PROCESS
Wire as small as

1/100,000 { OF AN INCH IN DIAMETER

. . . available in Platinum and some other Metals

.00001" is less than 1/30 the diameter of the smallest wire die commercially available. Yet our Wollaston Process wire (drawn in a silver jacket) closely meets your specifications for diameter, resistance and other characteristics.

This organization specializes in wire and ribbon of smaller than commercial sizes and closer than commercial tolerances. *Write for List of Products.*

SIGMUND COHN & CO.
SINCE 1901
44 GOLD STREET NEW YORK 7

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from BRASS to PLASTIC ...a Change for the Better!

When Consolidated originally developed the transfer mold for this intricate Terminal Block (illustration A), provision was made for a multiplicity of threaded brass inserts—and while it meant no trouble for us to add two more inserts for the projecting switch stops . . . trouble did occur in actual service; it was difficult for the brass stops to maintain their functional accuracy.

As "Accuracy Headquarters," this problem became Consolidated's problem! . . . And in illustration (B) you now see the solution . . . plastic stops . . . integrally molded, to closest tolerance, right into the piece. According to customer's reports, this change proved eminently satisfactory!

We cite this as an example of Consolidated's flexibility. Our know-how with mold design, mold making and processing is such as to permit changes —incorporate improvements—and thus assure perfect performance.

The above is also indicative of Consolidated's desire to serve. Inquiries invited from those whose present problems or plans have reached the thinking-out stage. Consolidated guarantees your blueprint in plastic—the right plastic!

INJECTION molding
TRANSFER molding
COMPRESSION molding

"YOUR BLUEPRINT IN PLASTIC"

CMP

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MOLDED PRODUCTS *Corporation*
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PERMANENT MAGNETS

Specializing in the production of highest quality Alnico Magnets in all grades including new triple strength No. 5.

Production material checked to assure highest uniform quality of product.

Castings made to customer's special order on the basis of sketches or blueprints furnished.

Information and suggestions furnished on request.

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MANUFACTURERS OF HIGH COERCIVE MAGNETIC ALLOYS

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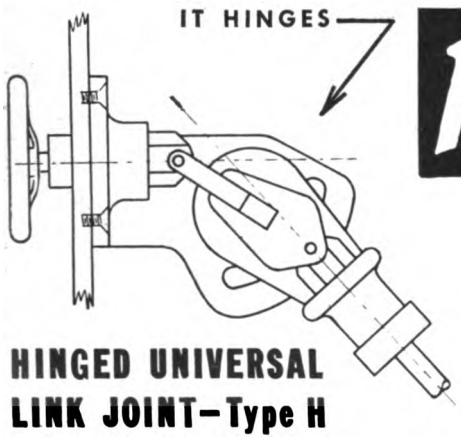

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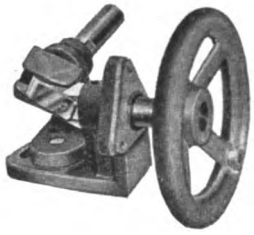

HINGED UNIVERSAL LINK JOINT—Type H

This Piezo universal link joint, new in principle, transmits motion around corners and permits operation of shafts at angles from 0° to 90°. Easily installed with solid shafting; flexing or backlash is negligible. The input and output shafts turn in exact angular rotation. It is recommended for operation of dial and rheostat controls, switches, variable condensers and transformers, coils, and other mechanical adjustments. Write for folder 45A giving complete data and specifications.

PIEZO MANUFACTURING CORPORATION

110 E. 42nd STREET, NEW YORK 17, N. Y.

Stokes MICROVAC Pumps

HEART OF HIGH VACUUM SYSTEMS

- Higher Vacuum (in the low micron range)
- High volumetric efficiency
- Low power requirement
- Complete discharge of air —no re-expansion
- Continuous dehydration of
- oil — no moisture to re-evaporate
- Discharges sudden slugs of liquid without injury
- Easily accessible, non-corrosive discharge valve
- Rugged, compact, simple construction
- Long life . . . negligible maintenance
- Five sizes—from 10 to 235 cu. ft. per min.

Stokes VACUUM GAUGES

(Patented McLeod Type)

Are Always Accurate

- Require no calibration
- Rapid readings
- Simple to operate—just tip and read
- Two models (AA) 0 to 5000 microns—(BB) 0 to 700 microns, with readings to 1/10 micron.

F. J. STOKES MACHINE CO.

6046 Tabor Road Philadelphia 20, Pa.

Stokes *High Vacuum*

PUMPS • GAUGES • EQUIPMENT

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DOW CORNING

SILICONES increase permissible operating temperatures by more than 100°C.

Today many accepted engineering limitations are being swept away by revolutionary new Dow Corning silicone materials. Designers are making major product improvements—coupled with important economies—never before possible.

Here's a specific example. Dow Corning varnishes and resins—because of their unique resistance to high temperatures—make it possible to redesign or rewind electrical equipment for increased horsepower output per unit weight. At the same time they greatly prolong equipment life under adverse operating conditions and reduce overload failures and fire hazards.

The recent development of DC 996, a Silicone Varnish which cures at 300°F., enables any electrical maintenance or rewind shop to secure the greater operating economies of Silicone Insulation.

In other industries Silicone materials also make possible operations which were previously impossible or very expensive. Consult Dow Corning for particulars.

IN THE ELECTRICAL INDUSTRY, FOR EXAMPLE

This test motor wound with Silicone Insulation has been alternately saturated with moisture and operated at 310°C. (590°F.) by resistance, for a total of 2,000 hours with no sign of failure. Silicone Insulation means reliable and continuous operation under most adverse conditions.

DOW CORNING CORPORATION
MIDLAND, MICHIGAN
NEW YORK OFFICE: EMPIRE STATE BUILDING

Dow Corning

FIRST IN SILICONES

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GOAT PRECISE-FORMED STAMPINGS

Save Money in quantity production

New techniques in construction and use of high speed, automatic, single operation, multiple-stage, progressive dies, in conjunction with the GOAT Precision Feed (U. S. Pat. No. 2,250,520), make possible: higher production speeds, lower scrap losses, less tool maintenance, overall lower costs, and closer tolerances than ever before possible. On lots of 500,000 or more the savings are indeed worthwhile.

Submit samples or drawings for cost estimates

LET US REDESIGN FOR STAMPING 3

GOAT METAL STAMPINGS, INC.
Affiliate of The Fred Goat Co., Inc.
314 DEAN STREET BROOKLYN, N. Y.

AMPERITE

THERMOSTATIC METAL TYPE

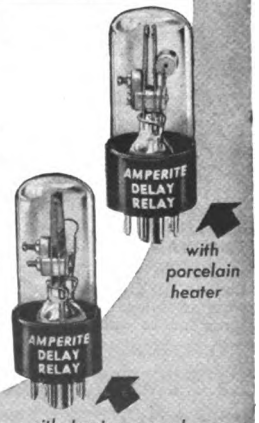
DELAY RELAYS

PROVIDE DELAYS RANGING FROM 1 TO 120 SECONDS

Other important features include:—

1. Compensated for ambient temperature changes from —40° to 110°F.
2. Contact ratings up to 115V-10a AC.
3. Hermetically sealed — not affected by altitude, moisture or other climate changes . . . Explosion-proof.
4. Octal radio base for easy replacement.
5. Compact, light, rugged, inexpensive.
6. Circuits available: SPST Normally Open; SPST Normally Closed.

WHAT'S YOUR PROBLEM? Send for "Special Problem Sheet" and Descriptive Bulletin.



with porcelain heater

with heater wound directly on blade

AMPERITE CO. 561 BROADWAY NEW YORK 12, N. Y.
In Canada: Atlas Radio Corp., Ltd.
560 King St. W., Toronto

American Beauty

ELECTRIC SOLDERING IRONS

are sturdily built for the hard usage of industrial service. Have plug type tips and are constructed on the unit system with each vital part, such as heating element, easily removable and replaceable. In 5 sizes, from 50 watts to 550 watts.

TEMPERATURE REGULATING STAND

This is a thermostatically controlled device for the regulation of the temperature of an electric soldering iron. When placed on and connected to this stand, iron may be maintained at working temperature or through adjustment on bottom of stand at low or warm temperatures.

For further information or descriptive literature, write

907-4

AMERICAN ELECTRICAL HEATER COMPANY
DETROIT 2, MICH., U. S. A.

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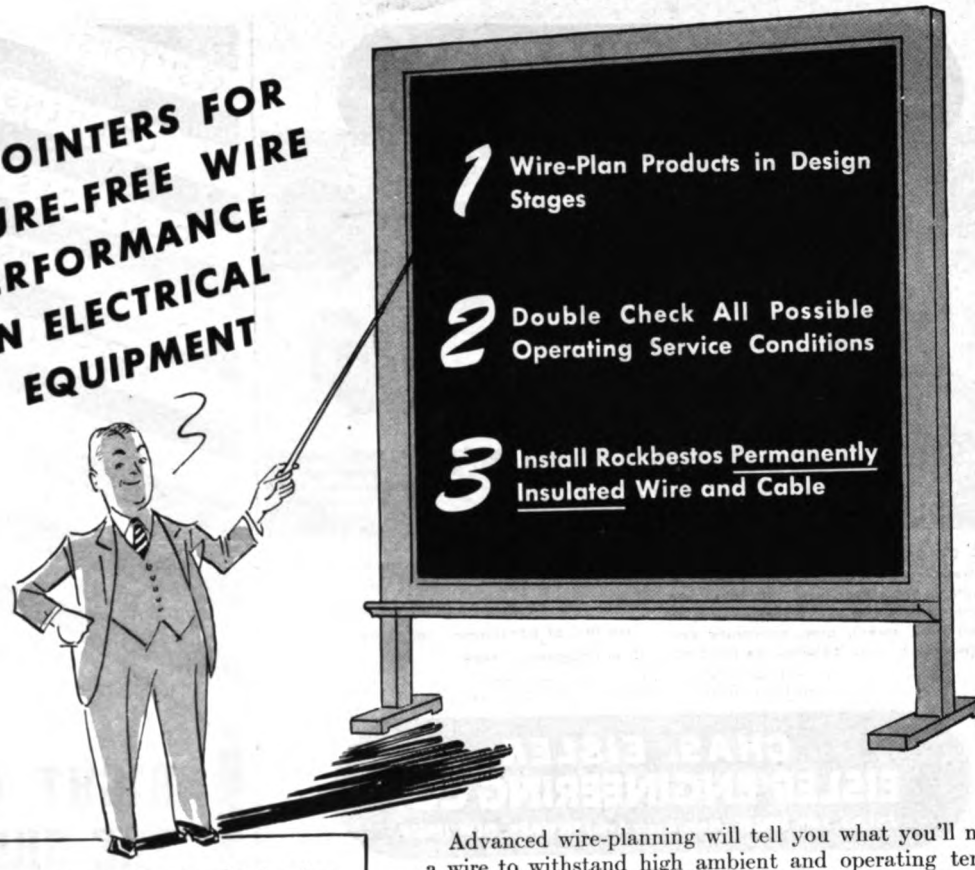
3 POINTERS FOR FAILURE-FREE WIRE PERFORMANCE IN ELECTRICAL EQUIPMENT



125 different permanently insulated wires, cables and cords developed by Rockbestos to meet unusual and severe operating conditions.

ROCKBESTOS FIREWALL RADIO HOOKUP WIRE

Sizes No. 22 to 4 AWG in 1000 volt rating, and No. 12, 14 and 16 AWG in 3000 volt.

The first lightweight, small diameter, flame-resistant hookup wire, designed in 1937 and widely used since in airborne and ground communication systems, electronic devices, instruments and apparatus. Operating temperatures range from 125° C. to minus 50° C. Also with tinned copper shielding braid and in twisted pair or tripled construction.

ROCKBESTOS TYPE CA LEAD WIRE

Has high-dielectric strength and moisture resistance for use where heat and humidity are encountered. No. 20 to 8 AWG solid or stranded copper, monel or nickel conductors insulated with synthetic tape and various thicknesses of felted asbestos finished in black, white or colors for coding purposes. Also with All-Asbestos insulation only, for high temperature applications where moisture resistance is not required.

ANOTHER NEW ROCKBESTOS FIREWALL CONSTRUCTION A 400°F. WIRE

War-developed Rockbestos High-Temperature Wire—*with a maximum operating temperature of 400°F.*—designed for jet propelled plane applications and circuits to hot-wing de-icers, fire detectors and extinguishers, and air conditioning and heating units where baking temperatures destroy ordinary insulation. Under continuous operation at rated temperature it retains its original dielectric strength and inherent resistance to heat and flame, and *progressively improves* in its resistance to moisture and abrasion. Now available for these and other severe applications. Write for complete information and samples.

Advanced wire-planning will tell you what you'll n a wire to withstand high ambient and operating tem tures, abrasion, vibration, overloads, moisture, oil, gre

Checking actual operating conditions and adding safety margins will help take care of the unusual requirements that the product gets in operation.

Installing Rockbestos wires, cables and cords give products trouble-free wire performance under severe ating conditions.

Inherently heatproof and fireproof, *permanently in* Rockbestos has an *impregnated asbestos insulation* tha stands conductor-heating overloads and high ambie won't dry out, crack or bake brittle. Because the ins resists oil, grease, moisture and alkalies, it won't rot bloom or swell.

Rockbestos wires, cables and cords are available standard constructions . . . each and every one has *manent asbestos insulation* that assures long-lived perfo under severe conditions. And for applications where a ard won't do . . . Rockbestos Research will go to wor "special" construction to meet your particular require For samples, wire recommendations or wire assistance nearest district office or:

ROCKBESTOS PRODUCTS CORPORATION

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Solves Difficult Wiring Problem

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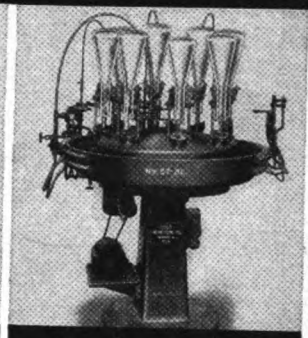
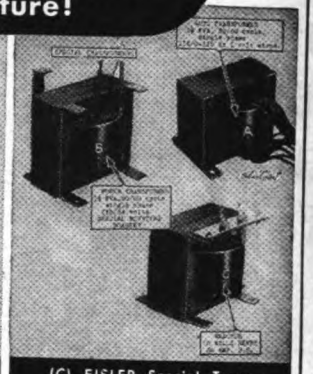
EISLER EQUIPMENT

..complete and diversified for every phase of electronic* manufacture!

(A) No. 600-KC3P, 50 KVA Press Type Spot Welder, 3 Spots, Air Operated, 18" Throat—a high production unit.



(B) No. 57-8L New Eisler 8 head type Tipless Sealing Machine. Adaptable for all types and sizes of bulbs.



(C) EISLER Special Transformers and Reactors — high or low voltage; air cooled, oil immersed or uncased.

The CHAS. EISLER line of specialized electronic tools, machines and devices is complete and diversified. Included are innumerable types of welders — spot, seam, butt, rocker, arm, pneumatic and special types. Also included are hundreds of devices for vacuum tube manufacture — glass tube cutters, slicers, stem and sealing machines as well as an all-inclusive line of transformers for every industrial and general need.

* EISLER serves 99% of American vacuum tube producers today. Write for completely illustrated catalog.

CHAS. EISLER
EISLER ENGINEERING CO.

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RESISTORS
CONDENSERS
CONTROLS • WIRE
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★ Front panel will match finish of cabinets.

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PROMPT DELIVERIES—Send us your bare fabricated steel and within two weeks we will return it finished and marked to your complete satisfaction.

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ALSO . . .
SILK SCREENING on front panels and chassis, either metal or plastic. Sharp clear characters durably printed on finished or unfinished surfaces.

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BECKMAN Helipot

Now available for civilian electronic applications!

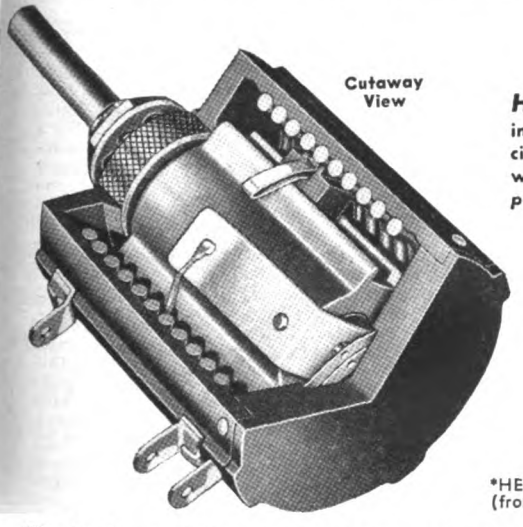
Can you use this important development to improve your product?

THE HELIPOT—a Beckman development widely used during the war on such precision instruments as radar, flight control units, depth sounding devices, and other critical electronic equipment—is now available to manufacturers and users of civilian electronic instruments!

The Beckman Helipot is a unique *new type* of potentiometer-rheostat which combines in *one compact unit* both the wide resistance range and extreme fineness of adjustment heretofore usually obtainable only through use of *two* separate rheostats, *two* control knobs, *two* adjusting operations. It is outstanding for all types of precision electronic equipment requiring high linearity, wide range and precise resistance control.

WHAT IT IS: The Beckman Helipot consists of a long, precision slide wire coiled helically into a small case and equipped with a slider contact assembly that is moved in the usual manner—by rotation of a shaft. A simple device automatically guides the slider contact over the helical path of the resistance winding so that the entire length of the wire can be contacted by rotation of *one* knob.

This unique design enables the Helipot to occupy no more panel space than a conventional single-turn rheostat. Yet the greatly increased length of the resistance winding provides a new standard of high accuracy *and* wide resistance range *in one unit*. It means, for example, that a ten-turn Helipot has *ten times the fineness of adjustment* possible with a single-turn rheostat of the same range. Or conversely, for the same fineness of adjustment a ten-turn Helipot has *ten times the range.*



Cutaway View

IMPORTANT HELIPOT FEATURES

High Linearity—As a result of fulfilling wartime requirements for ultra-precision circuit controls, Helipots are mass-produced with linearity tolerances of *one tenth of one per cent*—and even less!

Precise Settings—Because of the many-times longer slide wire, settings can be made with an accuracy impossible with single turn units.

Wide Range—By coiling a long potentiometer slide wire into a helix, the Helipot provides *many times* the range possible with a single turn unit of comparable diameter and panel space requirements.

Low Torque—Of special interest for power-driven applications—the Helipot has unusually low torque characteristics. The 1½" Helipot, for example, has a torque of *only one inch-ounce.*

Write for further details!

*HELIPOT—T. M. Reg. (from HELIcal POTentiometer)

The Beckman Helipot is precision-built of the finest materials and is designed for use in all types of high quality electronic instruments where accuracy, sensitivity, wide range and positive operation are required. Why not investigate its use to increase the accuracy, the convenience, the efficiency of your quality electronic products? Our engineers will be glad to explain how the Helipot can fit your application. Write, briefly outlining your needs and ask for Helipot Bulletin!

VARIOUS SIZES AND TYPES

Current Helipot production is in several types and sizes, including . . .

Diameter	No. of Turns	Total Length Slide Wire
1½"	Up to 10	Up to 44"
3"	Up to 40	Up to 378"

Other sizes available on special order.

THE Helipot CORPORATION, South Pasadena 2, Calif.

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ATTENUATORS by TECH LABS

MIDGET TYPE 600

"Midget" model is especially designed for crowded apparatus or portable equipment.

STANDARD TYPE 700

- Solid silver contacts and stainless silver alloy wiper arms.
- Rotor hub pinned to shaft prevents unauthorized tampering and keeps wiper arms in perfect adjustment.
- Can be furnished in any practical impedance and db. loss per step upon request.
- TECH LABS can furnish a unit for every purpose.
- **Write for bulletin No. 431.**

TECH LABORATORIES

Manufacturers of Precision Electrical Resistance Instruments

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1-INCH MB METERS

FOR THAT PORTABLE EQUIPMENT YOU'RE PLANNING

SPACE-SAVING AND WEIGHT-SAVING, these miniature meters provide design simplicity . . . *with no sacrifice in accuracy.*

Scales are sharply defined—easy to read. Accuracy is within the 2% specified in the AWS. And they're engineered and constructed to retain that calibration . . . with extremely light, sensitive moving element, Alnico No. 5 magnet, precision pivots, jewel bearings, hermetical sealing . . . and many other quality features. Shock, vibration, temperature extremes, moisture are resisted successfully.

These 1¼ oz. instruments have the requisite sensitivity for many electronic applications. And for other purposes where the measured quantity depends upon electrical variations. Available in standard DC ranges from 100 microamperes through 10 milliamperes . . . and 0-10 and 0-50 millivolts. Adapted to other ranges with standard shunts, multipliers, rectifiers.

MB also presents a 1½ oz., 1½ inch series, self-contained in all standard DC ranges, and rectifier AC voltmeters and milliammeters.

THE MB MANUFACTURING COMPANY, INC.

ELECTRICAL METERS FOR AIRCRAFT AND PORTABLE EQUIPMENT

Instrument Division

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ZOPHAR

Fungus-Proofed Waxes

As a vital service to the Armed Forces we now offer Fungus Resistant Materials. These recently developed products are the answer to Communications requirements where the impregnation or coating of radio parts and equipment are concerned.

ZOPHAR waxes and compounds meet every specification of both the Army and Navy for waterproofing and insulating all electrical and radio components. They also have wide application in packaging of every description.

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"The war has sharply demonstrated that the service of railroads is indispensable and that private ownership, management and operation are able and efficient. Now that the war is over, railroad plants should be modernized to take advantage of new things learned during the war years and to permit operation under new and higher standards. Railroad radio is one of these new developments, and, as a means of communication, has already been installed experimentally at several points in yard operation and its experimental use on certain sections on our main line is planned."

G. Metzman

President, New York Central System

Mr. Metzman's statement symbolizes the forward-looking thinking of top railway management today. The railroads *are* going forward, with improvements and modernization designed to increase the efficiency and safety of all types of operations.

The Farnsworth Television & Radio Corporation, through its recent acquisition of the Halstead Traffic Communications Corporation, is playing an increasingly important part in furthering these aims. Halstead Systems provide a factor of safety unique to the field of mobile communications. A radio counterpart of the closed-circuit principle, perfected during the war, is contained in the exclusive "auto-pulse" unit, standard on all Halstead equipment, whether AM or FM, space or induction type systems.

The combined talent of Farnsworth and Halstead research and engineering, together with Farnsworth's productive skills and facilities will keep in step with the railroads' growing interest in mobile communications.

For specific information, write Farnsworth Television & Radio Corporation, Dept. E-12, Fort Wayne 1, Ind.

FARNSWORTH TELEVISION & RADIO CORPORATION

Farnsworth Radio and Television Receivers and Transmitters • Aircraft Radio Equipment • Farnsworth Television Tubes • Halstead Mobile Communications and Traffic Control Systems for Rail and Highway • the Farnsworth Phonograph-Radio • the Capehart • the Capehart-Panamuse

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SINCE 1934

TYPE Z-1

THE NEW STANDARD CRYSTAL UNIT FOR ALL HIGH FREQUENCY SERVICE

FREQUENCY 1.5 TO 10.5 MC.
TEMPERATURE COEFFICIENT LESS THAN 2 CYCLES PER MC. PER DEGREE CENTIGRADE
CALIBRATION ACCURATE TO WITHIN .005% OF SPECIFIED FREQUENCY

MADE BY

PETERSEN RADIO COMPANY
COUNCIL BLUFFS, IOWA

Solder Fast

TRIGGER CONTROL
EASY HANDLING

Pats. Pending

● The BAKER Flash is the revolutionary gun-type soldering iron that answers industry's demand for a FASTER, HANDIER tool.

The tip flashes to soldering heat almost instantly following pressure on the trigger control. Correct temperature for most efficient work is easily maintained, over-heating and unnecessary oxydation avoided, cleaning and re-tinning time saved.

Natural gun grip; cool, protected plastic handle; light weight; perfect balance—these are advantages that make the BAKER Flash extremely easy to use, *ideal for work in close places.*

Completely equipped for immediate operation from 110-volt transformer or from standard storage battery.

Write or Wire for Complete Information

THE YEAR'S BIGGEST NEWS IN SOLDERING

●

ORDER SAMPLE TODAY—Only $4.75 Postpaid with Transformer $8.95—Send check or Money Order

BAKER-PHILLIPS CO. 3057 LYNDALE AV. SO. MINNEAPOLIS 8, MINNESOTA

THE VIBRATION-PROOF SHOCK-PROOF EBY MINIATURE TUBE SOCKET

The ideal miniature socket for

RAILWAY • AIRCRAFT
AUTOMOTIVE
and other commercial radio and electronics equipment

Now available for commercial use—the famous Eby miniature tube socket, the only socket meeting specification JAN-5-28 for military aircraft use.

Developed to meet the *most rigorous* service conditions of constant vibration and shock, the peace-time applications of this socket are readily apparent.

The use of the Eby miniature tube socket with special beryllium copper contacts assures minimum tube breakage and maximum uninterrupted operation of equipment.

Can be supplied with shock shield and protective cover or saddle type.

(Also available with phosphor bronze contacts for home radio receivers.)

Write today for Samples and Prices of the Eby Vibration-proof, shock-proof miniature tube socket.

HUGH H. EBY
INCORPORATED
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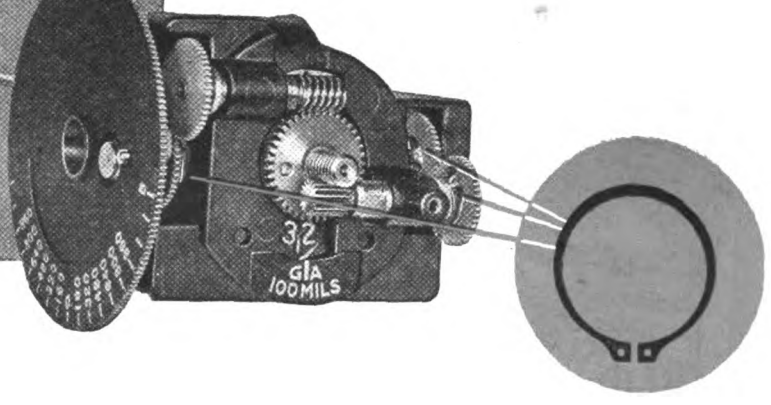
Sperry FOUND A BETTER WAY

TO HOLD MACHINE PARTS TOGETHER

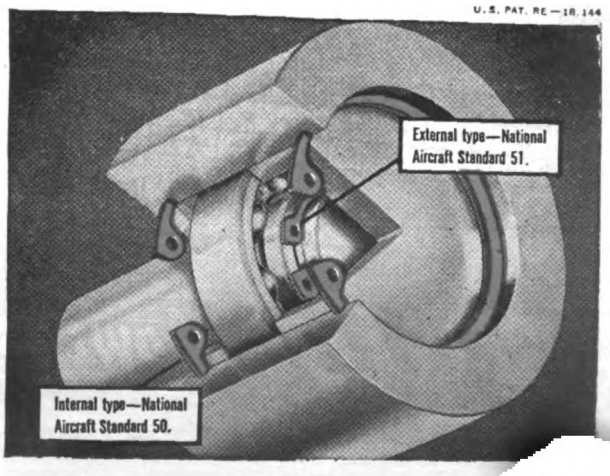
WALDES TRUARC RETAINING RINGS

Before using Waldes Truarc Retaining Rings in Sperry gunsights, Sperry Gyroscope Co. engineers had difficulty with important taper pins working loose while the gunsights were in service. Due to vibration, pins occasionally loosened and fell out affecting the accuracy of the gunsights. Frequent, thorough inspection of taper pins in use didn't entirely solve the problem.

Then they specified Waldes Truarc Rings. Where taper pins had previously worked loose, the rings now held them fast. Assembly of the gunsights became much easier and quicker. Because of this earlier experience, Sperry used Waldes Truarc Rings as original equipment in their K-13 Compensating Gunsights. And Truarc *exceeded* their highest requirement for dependability in action.



aldes Truarc Retaining Rings are used to save weight, space, st and man-hours in a wide range of products. For holding d positioning machine parts they offer definite advantages er nuts, shoulders, collars, and pins. They simplify and speed up oduction. They can be put on and taken off again and again and still retain the perfect circularity which gives them their failing grip. Test them yourself. We'll furnish samples and mplete data. Write Dept. H-12.



WALDES TRUARC RETAINING RINGS

WALDES KOHINOOR, INC., LONG ISLAND CITY 1, NEW YORK

CANADIAN REPRESENTATIVES: FRENCO PROGRESS CORP., LTD., 72-74 STAFFORD ST., TORONTO

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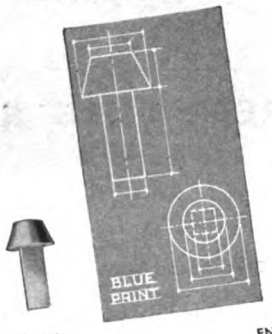
ANOTHER SPECIAL BY PROGRESSIVE

QUALITY PROMCO BRAND



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CATALOG SHOWS DOZENS MORE

Special heads, threads and finishes on any metal or alloy adapted to cold upset. Weekly output: 25,000,000 pieces. Many specials, suggesting production savings for you, illustrated in latest catalog. Includes weights per 1M standard pieces, dec. equivs. of fractions, other purchasing and engineering helps. Write for Catalog 18.

The PROGRESSIVE MFG. CO.

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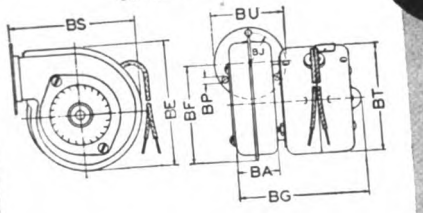
FASCO

Little Blowers do BIG Jobs efficiently...quietly

50745 BLOWER



MODEL 50745

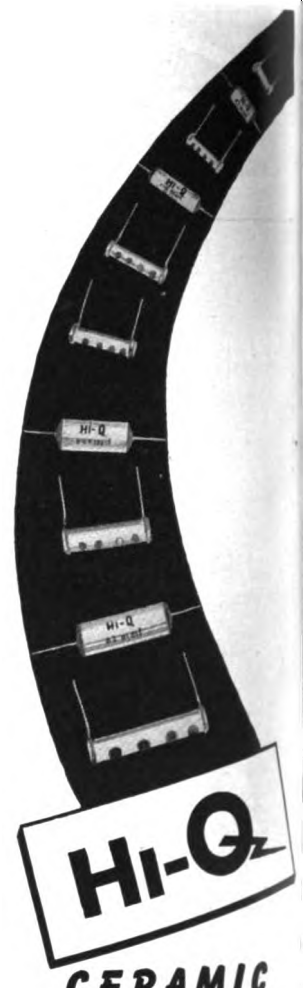
Typical applications of these small (15 to 100 C.F.M.) Blowers are air distribution in confined spaces such as: cooling radio and other electronic equipment; forced draft; exhausting fumes and gases. Write for Bulletin 3A-14 today.

DIMENSION CHART

BA	BE	BF	BG	BJ	BP	BS	BT	BU
1-5/16"	3-3/16"	3"	4"	15/16"	13/64"	3-29/32"	3-11/32"	3-1/4"

F. A. SMITH MFG. CO., INC., 801 Davis St., Rochester 2, N. Y.

Pilot BLOWERS



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CERAMIC CAPACITORS

● Available in Temperature Compensating and Hi-K type. Dielectric factors 19 to over 1200. Solid Silver condenser plates, non-aging and non-corrosive, gauged to thousandths of an inch, fused for long life performance.

Hi-Dielectric Enamel Finish withstands mechanical and thermal shock.

Color coded for accuracy in identification.

ELECTRICAL REACTANCE CORPORATION

FRANKLINVILLE, N. Y.

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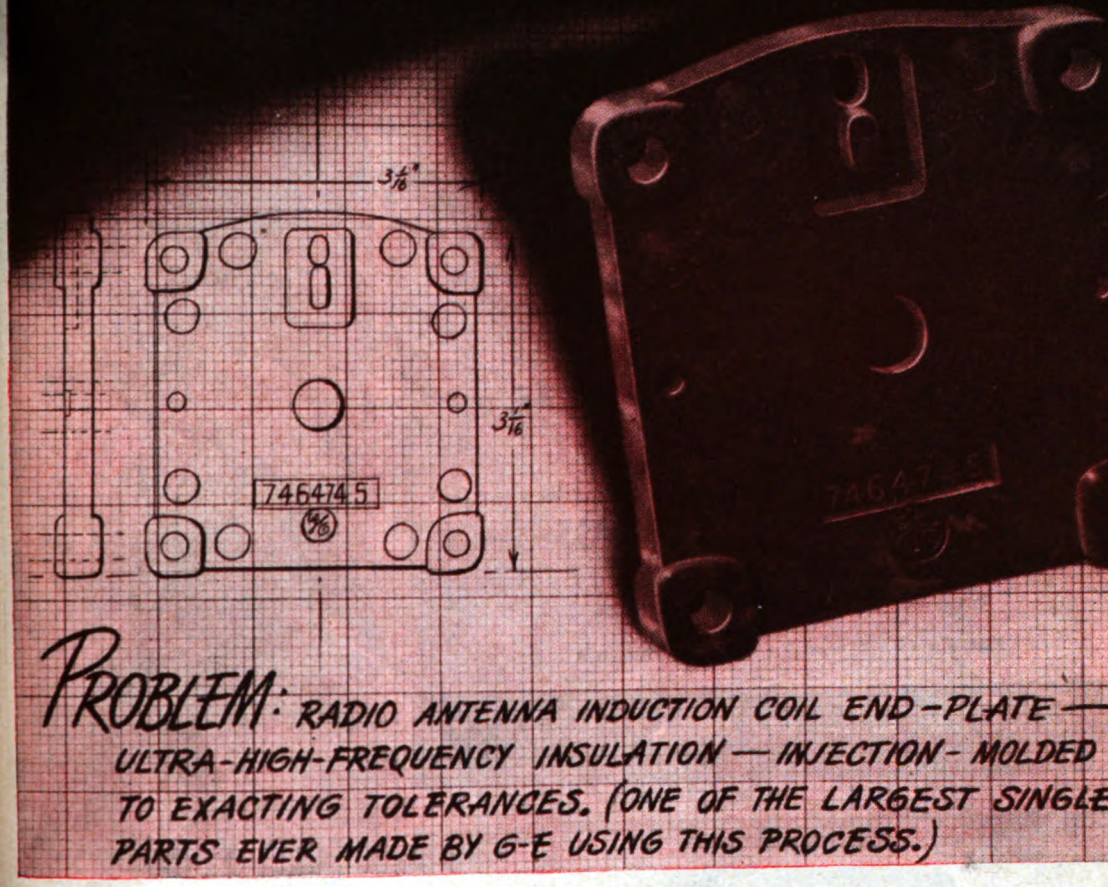

PROBLEM: RADIO ANTENNA INDUCTION COIL END-PLATE — ULTRA-HIGH-FREQUENCY INSULATION — INJECTION-MOLDED TO EXACTING TOLERANCES. (ONE OF THE LARGEST SINGLE PARTS EVER MADE BY G-E USING THIS PROCESS.)

A LARGE INJECTION-MOLDING OF G-E MYCALEX

● This is the end-plate of a radio antenna induction coil.

It is a large electrical component that has been injection-molded by G.E.'s complete plastics service from G-E mycalex—compound of glass and powdered mica with a unique combination of properties.

And it meets not only ultra-high-frequency insulation requirements, but exacting tolerances. Rejects of this part have been reduced to a negligible percentage by specifying G-E mycalex and injection-molding.

This success suggests wider future use of G-E mycalex, which is available to you in standard sheets and rods—or molded to your design. For information, write to Section S-5, Plastics Divisions, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

G-E MYCALEX

A Unique Combination of Properties

1. High dielectric strength
2. Low power factor
3. Prolonged resistance to elect arcs
4. Chemical stability—no deterior with age
5. Dimensional stability—freedom warpage and shrinkage
6. Imperviousness to water, oil, an
7. Resistance to sudden tempera changes
8. Low coefficient of thermal expa
9. High heat resistance

Samples Supplied on Request

MYCALEX

GENERAL ELECT

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LET US QUOTE ON YOUR

SMALL STAMPINGS

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SPECIAL TERMINALS

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SOLDERING LUGS

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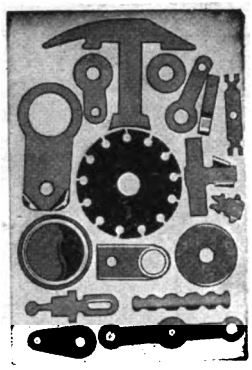

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on Medium and Large Quantities

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D.C.
to A.C.
CONVERTERS

An Inverted Rotary Converter is a rotating electrical machine for converting direct to alternating current.

Janette was one of the first manufacturers to design, build and develop rotary converters for use with numerous A.C. devices; especially those using electronic tubes. Since their inception they have established a world wide record for reliable, efficient, quiet, trouble-free operation under the most adverse conditions. **Two types are built:** one for standard and special commercial uses; the other for marine service.

Ask for Bulletin 13-25 for COMMERCIAL Type Converters
or **Bulletin 13-27** for the MARINE Type

Janette

Janette Manufacturing Co. 556 W. Monroe St. Chicago 6, Ill.

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wherever a tube is used . . .

for example:

AUTOMATIC DOOR CONTROL

Doors that operate automatically save man-hours where plant traffic is heavy, cut heating costs, reduce breakage in restaurants, are a convenience to package laden shoppers. The electronic principle involved has hundreds of commercial and industrial applications.

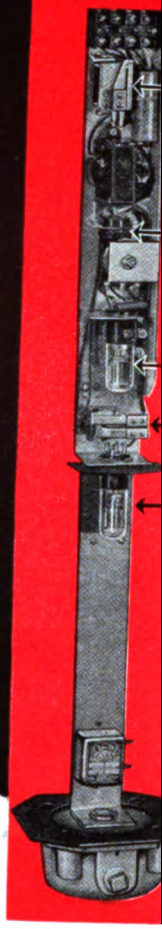

PHOTO-ELECTRIC DOO
Above unit manuf
General Electric Co.,
STANLEY "MAGN
CONTROLS.

THERE'S A JOB FOR *Relays* BY GUARDIAN

★ The "Magic Door" made by The Stanley Works of New Britain, Conn., uses a General Electric control unit which operates automatically at the approach of a pedestrian or vehicle. In this unit a beam of light focused on the cathode of a phototube causes a tiny current to flow. Enlarged through an amplifier tube this current operates a sensitive telephone type of relay such as the Guardian Series 405. Another phototube with an auxiliary relay, Guardian Series R-100, is employed to hold the doors open for anyone standing within the doorway.

The telephone type of relay is extremely sensitive and able to operate on the small current supplied through the electronic circuit. The auxiliary relay, Series R-100, is required to handle a greater current. It is a small, efficient relay having a contact capacity up to 1 KW at frequencies up to and including 28 megacycles. Contact combinations range up to double pole, double throw. Standard coils operate on 110 volts, 60 cycles, and draw approximately 7 V. A. Coils for other voltages are available. For further information write for Bulletin R-6.

Consult Guardian whenever a tube is used—*however*—Relays by Guardian are NOT limited to tube applications but are used wherever automatic control is desired for making, breaking, or changing the characteristics of electrical circuits.

Series 405 Telephone T

Series R-100 H. F.

GUARDIAN ELECTRIC

1625-P W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

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GOLD PLATED SILVER FOIL

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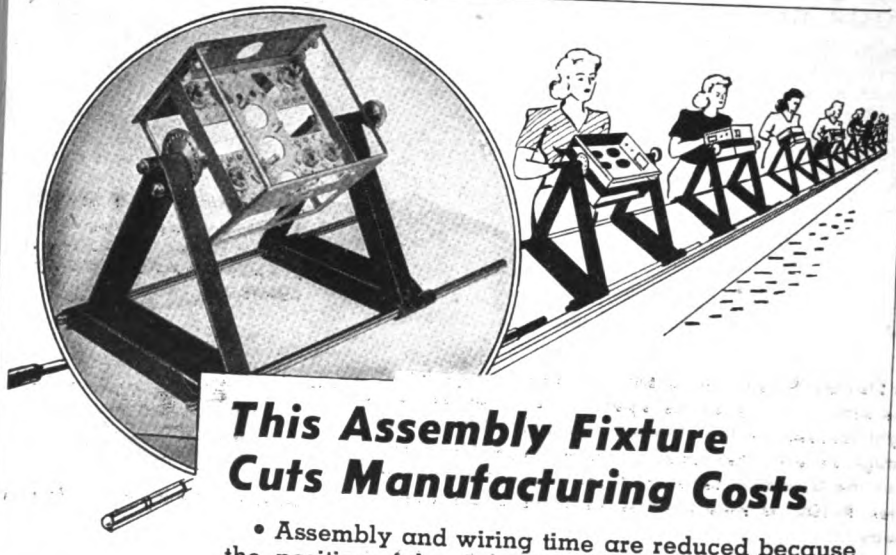

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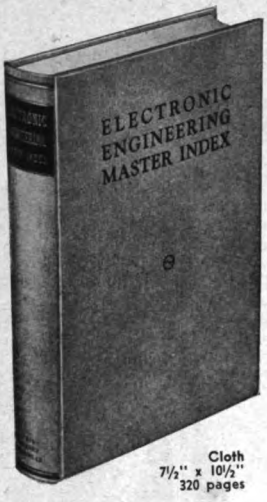

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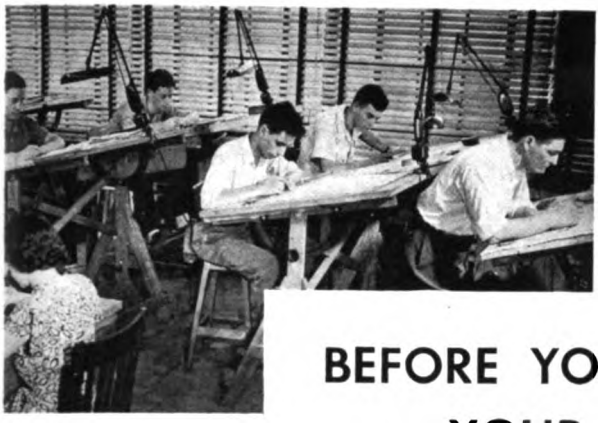

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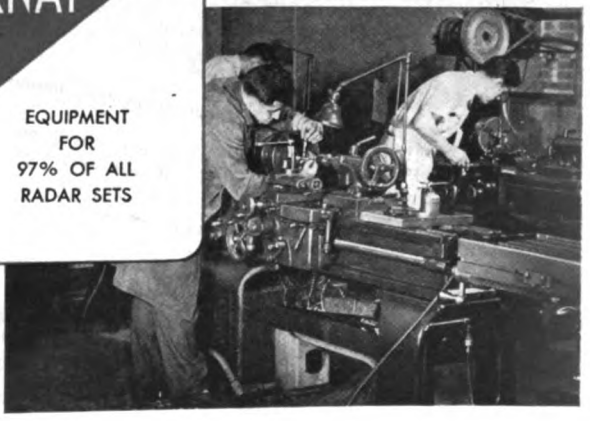

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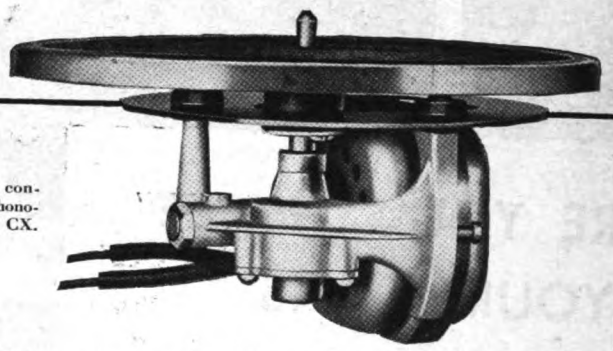

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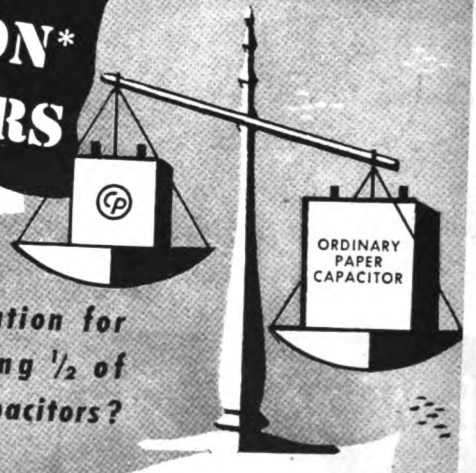

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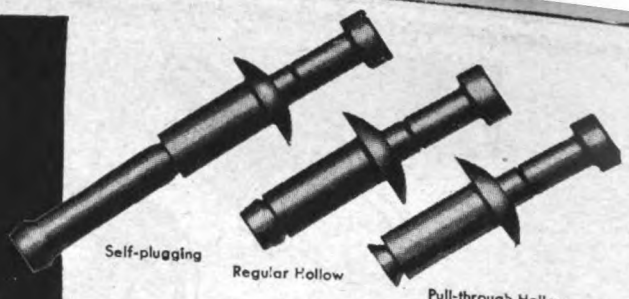

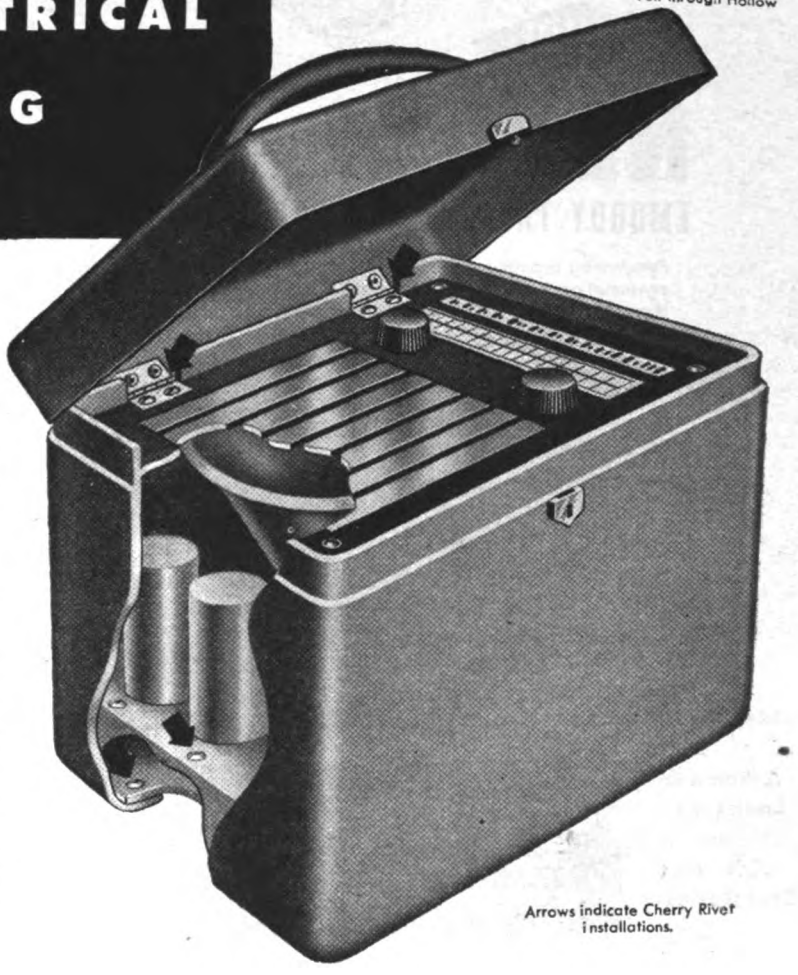

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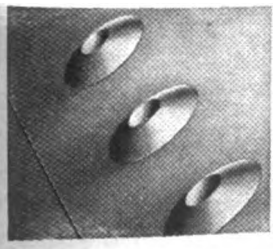

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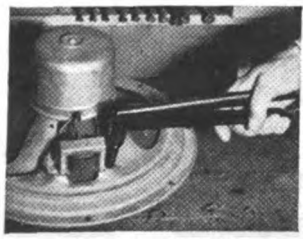

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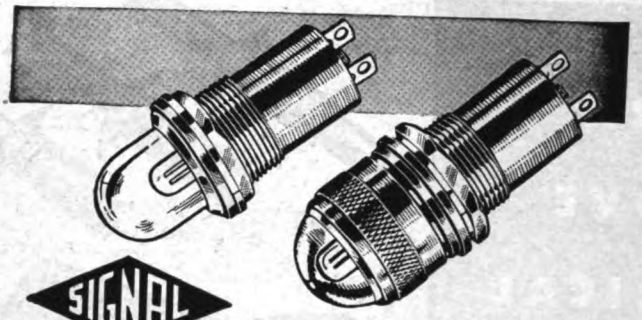

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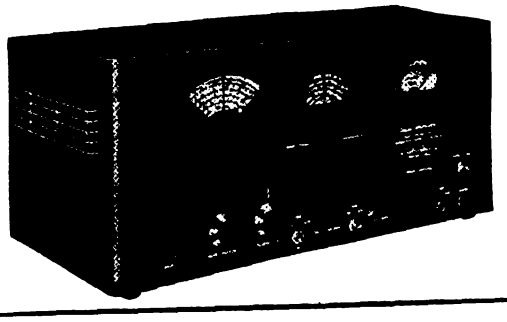

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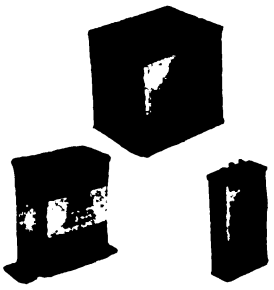

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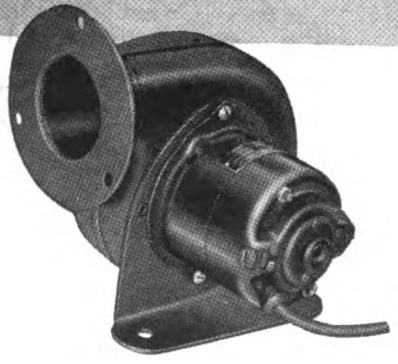

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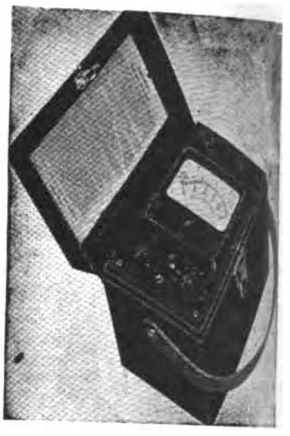

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TRANSMITTING TUBES
Inquiries Invited—Let us explain how Savings are effected and the F & O greater guarantee.
FREELAND & DLSCHNER PRODUCTS Inc.
611 Baronne St., New Orleans 13, La.
Raymond 4756
High Power Tube Specialists Exclusively
(5 KW To 100 KW)

REX RHEOSTATS
REX RHEOSTAT COMPANY, BALDWIN, L. I., N. Y.
PROTECTED & UNPROTECTED
RHEOSTATS
WITH LUBRICATED CONTACTS
ROTARY DRIVE RHEOSTATS
WITHOUT BACK LASH
PROTECTED & UNPROTECTED
ADJUSTABLE RESISTORS
UP TO 1000 WATT
PROMPT SHIPMENTS

We manufacture a complete line of equipment
SPOT WELDERS, electric from ¼ to 50KVA
TRANSFORMERS, special and standard types
INCANDESCENT LAMP manufacturing equipment
FLUORESCENT TUBE MAKING EQUIPMENT
ELECTRONIC EQUIPMENT, vacuum pumps, etc.
WET GLASS SLICING and cutting machines for laboratory use
GENERAL GLASS working machines and burners
COLLEGE GLASS working units for students and laboratory
AC ARC WELDERS from 100 to 400 Amps
EISLER ENGINEERING CO.
731 So. 13th St. (near Avon Ave.) Newark, New Jersey

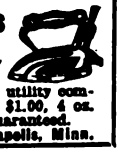
FINE RIBBONS
OF
TUNGSTEN and MOLYBDENUM
Quality and accuracy in our fabrication of Tungsten & Molybdenum Ribbons have characterized our service to the Electronic industry.
A development of
H. CROSS CO.
15 Beekman St., New York 7, N.Y.

Electron Tube Machinery
of every type,—standard, and special design
Specialists in Equipment for the manufacture of Radio Tubes, Cathode Ray Tubes, Fluorescent Lamps, Incandescent Lamps, Neon Tubes, Photo Cells, X-ray Tubes and other glass or electronic products, on production or laboratory basis.
Kahle
ENGINEERING COMPANY
1307-1309 Seventh St., North Bergen, N. J.

MICROMETER FREQUENCY METER
for checking Transmitters from 1.5 to 56 mc., within 0.01 per cent
LAMPKIN LABORATORIES
Bradenton, Fla., U. S. A.

BRAZILIAN QUARTZ CRYSTALS
CRYSTAL TRADING COMPANY
Importers
118 Liberty St. New York 6, N. Y.

Burned Out or Broken Electric Heating Elements



repaired with NICHROCITE PASTE. Simply overlap ends, apply paste, turn on current. Used by utility companies, etc. Family size, $1.00, 4 oz. size $2.50. Satisfaction guaranteed.
Armstrong Mfg. Co., Box 561G Minneapolis, Minn.

HETERODYNE ELIMINATORS
If you are troubled by heterodyne interference consult
J. L. A. McLaughlin
P. O. Box 529, La Jolla, Calif.

MINIATURE PRECISION BALL BEARINGS
(WORLD'S SMALLEST BALL BEARING)
For precision instruments, industrial laboratory equipment, radio and electronic devices, to minimize friction, space, weight and overcome starting torque. Radial and Pivot types.
ACTUAL SIZES
ENLARGED SIX DIAM.

Radial Series (5 Sizes) 1/8" to 5/16" O. D.
Pivot Series (6 Sizes) 2 mm to 10 mm O. D.
Write for data sheet and catalog E
MINIATURE *Precision* BEARINGS
KEENE, NEW HAMPSHIRE, U·S·A·

FREE TO RADIO MEN

COLOR CODE and OHMS LAW CALCULATOR
Burstein-Applebee of Kansas City offers you this great convenience FREE. Easy to work. Solves many problems in a jiffy. FREE to radio men, electronic engineers and others in the business. Attach coupon to your letterhead.
MAIL COUPON NOW
BURSTEIN-APPLEBEE CO.
1012 McGEE, KANSAS CITY 6, MO.
Send me FREE Color Code and Ohms Law Calculator along with latest catalog.
I am_____
STATE CONNECTION IN INDUSTRY
NAME_____
ADDRESS_____
TOWN_____STATE_____

Make it a HABIT . . . to check this page—EACH ISSUE
THIS WHERE TO BUY SECTION supplements other advertising in this issue with these additional announcements of products and services essential to efficient and economical operation in the field of ELECTRONICS.

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SEARCHLIGHT SECTION

EMPLOYMENT • BUSINESS • OPPORTUNITIES • EQUIPMENT—USED or RESALE

UNDISPLAYED RATE:
15 cents a word, minimum charge $3.00. (See ¶ on Box Numbers.)
POSITIONS WANTED (full or part-time salaried individual employment only), ½ above rates.
PROPOSALS, 50 cents a line an insertion.

INFORMATION:
BOX NUMBERS in care of any of our New York, Chicago or San Francisco offices count 10 words additional in undisplayed ads.
DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:
The advertising rate is $7.50 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.
AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page.

NEW ADVERTISEMENTS received by 10 A. M. December 7th will appear in the January issue, subject to limitation of space available.

POSITIONS VACANT

(Additional Positions Vacant ads on pages 405 and 421)

WANTED: ENGINEERS with experience in Audio Circuit work for engineering development on hearing aids and associated devices. Experience on hearing aids not actually necessary. Apply to Chief Engineer Zenith Radio Corporation, 6001 W. Dickens Avenue, Chicago 39, Illinois, giving details of education, age and experience. These positions offer excellent opportunities for interested personnel.

WANTED: CAPABLE engineer in radio, television and tube design. Must be able to work in own home or shop. P-953, Electronics, 68 Post Street, San Francisco 4, Cal.

EMPLOYMENT SERVICE

SALARIED POSITIONS $2,500-$25,000. Reconversion is creating lifetime opportunities now. This thoroughly organized confidential service of 35 years' recognized standing and reputation carries on preliminary negotiations for supervisory, technical and executive positions of the calibre indicated, through a procedure individualized to each client's requirements. Retaining fee protected by refund provision. Identity covered and present position protected. Send only name and address for details. R. W. Fixby, Inc., 278 Delward Bldg., Buffalo 2, N. Y.

POSITIONS WANTED

RADIO ENGINEER. Interested in V.H.F. development, particularly multi-channel telegraph operation over V.H.F. radio links. (see page 237 August Electronics.) Recently returned from 3 years in charge of V.H.F. development section of British Admiralty. Desires position with company who might be interested in developing new ideas for V.H.F. communication. PW-936, Electronics, 68 Post Street, San Francisco 4, Cal.

ELECTRICAL ENGINEER: 6 years experience desires position in South in design and production small electric or electronic equipment possibly leading toward sales work. PW-954, Electronics, 330 W. 42nd St., New York 18, N. Y.

PHYSICIST, NOW head of research in large concern, desires responsible position as technical director in any research or manufacturing establishment. Age below forty. PW-955, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRONICS ENGINEER: M.A. in Physics, six years experience in the development and design of test equipment for radio and electronics manufacturers desires permanent position in electronic development in New England. PW-956, Electronics, 330 W. 42nd St., New York 18, N. Y.

E.E. COLLEGE graduate now employed in electronic industry desires permanent West-Coast position. Five years varied experience in circuit development, organization, and public contact. Excellent references and records available. $5,000. PW-957, Electronics, 330 W. 42nd St., New York 18, N. Y.

ELECTRICAL ENGINEER
Graduate, age 35 with 12 years experience, seeks position as Quality Control Manager or Chief Engineer, electrical and radio fields. Past 5 years executive and production experience directing inspection organization of 600 employees for company producing aircraft accessory equipment. (Small motors, electrical controls, radio). Previous experience design, development with leading radio manufacturers.
PW-949, Electronics
520 North Michigan Ave., Chicago 11, Ill.

Curt E. Patton Personnel Engineers
53 W. Jackson Blvd. Chicago 4
offer Industry a confidential Personnel Service, selecting and presenting men for positions open—on either a fee or retainer basis.
Outstanding men in electronic and allied fields, with legitimate reasons for seeking a change, are invited to file applications at NO CHARGE, in confidence, so we may present their qualifications to our clients.

WANTED

PHYSICISTS AND ENGINEERS

Unusual opportunities are offered to technical men in advanced fields of exploration, geophysics, applied physics and industrial electronics who wish, to live in a town of 20,000 and maintain a stimulating contact with associates of widely diverse technical skills.

Excellent laboratory facilities including equipment for electron microscopy, x-ray diffraction, mass and optical spectroscopy are available to a small but expanding group.

Opportunities are offered to physicists and engineers of imagination to gain wide recognition for their contributions to the solution of advanced problems.

PHILLIPS PETROLEUM COMPANY
RESEARCH DEPARTMENT
BARTLESVILLE, OKLAHOMA

LOUDSPEAKER DESIGN ENGINEER AND PRODUCTION MAN
Excellent present and future opportunity for the qualified men. Profit sharing and participation in company stock. Must have proved performance and dependability; good judgment plus know-how for straight line economical production. Our organization knows of this ad. Your fully detailed answer held in strict confidence.
P-947, (Agency) Electronics
330 West 42nd St., New York 18, N. Y.

POSITIONS WANTED

ENGINEER, INDUSTRIAL or low-frequency electronics, wants permanent position commuting distance New Canaan, Conn. Some experience production, development, laboratory, but most satisfactory in sales, technical writing. Prefers work involving people more than things. Johnson O'Connor tested; results available to prospective employer. Reason for availability—present employer closing New York branch. J. B. Campbell, P.O. Box 334, New Canaan, Conn.

MAN INHERENTLY Lazy, no college graduate, no correspondence schooling, but 20 years in U. of H.K. (University of Hard Knocks), in installation, maintenance, service and trouble-shooting on wiring, motors and generators, radio and radar. Anything in electronics considered (particularly industrial electronic control equipment) where I stand around and watch the other fellow work. More money and less work desirable. Midwest location. Present salary $6,000 per year. Available within the next 60 or 90 days. Give complete details in first letter. PW-958, Electronics, 330 W. 42nd St., New York 18, N. Y.

RADIO ENGINEER, M.S., E.E. degrees, experience in practical design and development, desires to join manufacturers of electronic instruments, transmitters, receivers, heating tubes, or parts as sales engineer and technical representative in China, many years radio business experience in China. PW-959, Electronics, 330 W. 42nd St., New York 18, N. Y.

(Continued on page 422)

Industrial designers!

Do you want to join a company which is out to give the buying public of the present and future the very best in product appearance? If you do, General Electric has a career job for you. The wide range of G-E products for the home offers fertile ground for imaginative, diversified designing. Industrial Designers on our payroll will therefore have an unprecedented opportunity to employ their talents in the creation of designs for G-E electrical appliances and apparatus and radio cabinets. Write now, giving your qualifications, to Mr. M. B. Tracy, Appliance & Merchandise Department, General Electric Co., Bridgeport, Conn.

ELECTRONIC ENGINEER
As research and design engineer with success into hearing aid company. Must be graduate E.E. Some electronic and acoustical experience desired. Unusual opportunity to progress with aggressive company. Compensation secondary to provable ability. Permanent position. Describe education, experience, aptitudes and age. State salary desired. Apply in complete confidence.
P-873, Electronics
330 West 42nd St., New York 18, N. Y.

for CAMERAS and PROJECTORS

Highly rated firm in the East manufacturing established line of amateur photographic equipment is interested in securing executive engineers or designers now commanding good salaries in camera goods or kindred type of work. Consideration given to original letters giving complete necessary details including home phone number, names of present or former employer, etc.

P-963, Electronics
330 West 42nd Street, New York 18, N. Y.

ENGINEER
HIGH QUALITY RADIO RECEIVERS
We need a high grade engineer who is thoroughly familiar with the design and production of radio receivers and has had several years experience. Knowledge of power and audio transformers also highly desirable. Small company located close to New York.
P. O. Box 430
Elizabeth, N. J.
or Elizabeth 2-1735

(Additional Positions Wanted & Selling Opportunity Advertising on Page 422)

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WANTED

SENIOR DEVELOPMENT ENGINEER

Large Midwest manufacturer has immediate openings in domestic radio and television receiver development for two Senior Radio Project Engineers and one Mechanical Engineer. Confidential inquiries respected.

P-813, Electronics
520 North Michigan Ave., Chicago 11, Ill.

WANTED

Assistant Chief Engineer

Midwest radio manufacturer requires an engineer to assume complete supervision of household and auto radio receiver development. Extensive prewar experience in above lines imperative. Television receivers will be in our line. All inquiries confidential.

P-814, Electronics
520 North Michigan Ave., Chicago 11, Ill.

Radio Engineers Wanted

for design and development of home radio receivers.
Can use men with exp. in design laboratories on communications and entertainment receiving sets. CALL OR WRITE

Mr. Frank A. Hinners
Vice pres: Chge. of Engineering
Air King Products
1523 63rd St., Bklyn 19, N. Y.

Permanent Employment

ELECTRONIC DEVELOPMENT ENGINEERS

Well-established Eastern Massachusetts concern desires graduate electronic engineers with flair for research and eye to future. Permanent position concerned at present with important development work for government with increased opportunities after the war. Unusual openings for men with capacity and initiative. Must be U. S. Citizens.

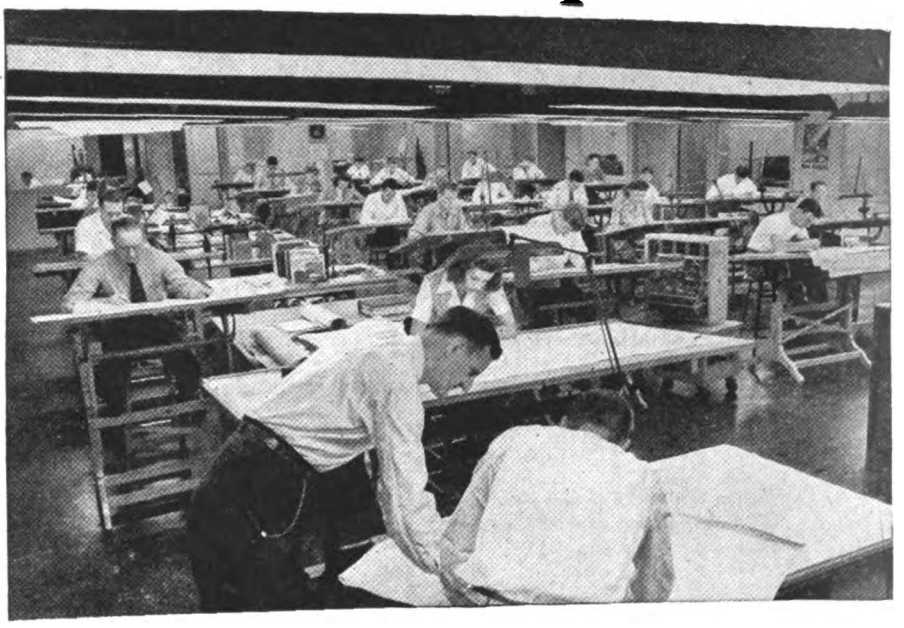
P-670, Electronics
330 West 42nd St., New York 18, N. Y.

WANTED

RESEARCH ENGINEERS

Prominent Radio Receiver Manufacturer located in Midwest has immediate openings for two research men with prewar development experience in the radio receiver or television field. Confidential inquiries respected.

P-815, Electronics
520 North Michigan Ave., Chicago 11, Ill.



Experienced Mechanical Drafting Design Engineers, Design Draftsmen, Junior and Senior Draftsmen

The Collins Radio Company has always been a pioneering organization—an *engineer's* engineering and manufacturing outfit.

It was the pioneering urge that led us to introduce professional standards of design and performance in transmitters and receivers for radio hams in the early thirties . . .

To plan and build special radio equipment that stood up to the rough-and-tumble of Admiral Richard E. Byrd's second expedition to Little America . . .

To take high quality broadcast equipment out of the laboratory and make it economically practicable for any broadcasting station . . .

To meet the individual requirements of some of the great airlines with specially engineered communication equipment, including the ingenious Collins Autotune.

To be prepared on December 7, 1941, to go into production of airborne and ground based radio gear of highly advanced design for the Armed Forces—the result of research and development looking years ahead.

We are looking far ahead today in the field of high quality radio communication equipment. Our post-war plans, well advanced, offer a very substantial opportunity for additional junior and senior draftsmen with at least three to five years of practical mechanical drafting, design, draftsmen with at least five years of experience in design drafting, and mechanical drafting design engineers with eight to ten years of mechanical design experience. Our work involves the production of small, intricate mechanical and electrical mechanisms.

This is a splendid opening for men and women who are able to make neat, accurate parts drawings with complete specifications, assembly drawings and layouts, who will assume responsibility, and who have knowledge of general standard shop and field practices. Cedar Rapids is a human, wholesome city of about 65,000. People enjoy living here. And people enjoy working, without being distracted by weather variations, in the modern controlled-conditions Collins plant.

If you feel that you could fit happily and capably into this organization, write us fully. Tell us about your education, experience, age, desired compensation and draft status. W.M.C. regulations, of course, must apply.

Address E. H. Reinschmidt,
Superintendent of Design,
Collins Radio Company,
Cedar Rapids, Iowa.

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Efficient Manufacturing Facilities Available

for sub-contracting

- ★ Sub-assembly and Complete Assembly Operations
- ★ Automatic - Screw Machines
- ★ Drilling, Tapping and Centerless Grinding
- ★ Electro-Plating

Facilities of three "E" Award manufacturing plants - conveniently located to insure "on schedule" production at the lowest costs - expert engineering service accustomed to precision manufacturing.

Company Representative will call to Discuss Details

John R. Wald Company

PHONE 682
HUNTINGDON, PENNSYLVANIA

Export for Profit

Roburn Agencies, Inc. have represented leading manufacturers of radio and electrical equipment, parts and accessories, in world-wide markets since 1935. Extensive facilities relieve you of all export headaches – correspondence, advertising, sales, finance, packing and shipping. A few additional clients seeking experienced, reliable representation are invited. Write for information on Profits Through Exports.

Roburn Agencies, Inc.
115E Fulton Street New York 7, N. Y.

REPRESENTATION IN TURKEY

A well known turkish radio company desires to represent American manufacturers of transmitters, receivers, sound systems, recorders, test and measuring equipment, dynamotors, converters and other electronic products. Write details to:

Mors Telsiz Atelyesi
Sisli P. K. 66
Istanbul Turkey

NATIONAL DISTRIBUTION AVAILABLE

For Manufacturers who make products suitable for sale to radio and electronic jobbers. We have a complete sales staff for national and export distribution. Reply with samples or description of products.

RA-870, Electronics
330 West 42nd St., New York 18, N. Y.

SALES REPRESENTATION EAST COAST

A group of experienced engineering consultants desire to represent manufacturers of Radio & Electronic products. Please reply with description of products.

RA-951, Electronics
330 West 42nd Street, New York 18, N. Y.

BEST QUALITY, USED ELECTRON TUBE MACHINERY

Equipment for the manufacture of all kinds of electron tubes, radio tubes, incandescent lamps, neon tubes, photo electric cells, X-ray tubes, etc.

AMERICAN ELECTRICAL SALES CO., INC.
65-67 East 8th St. New York, N. Y.

WANTED Your Business

"ANYTHING containing IRON or STEEL"

MORE FOR YOUR DOLLAR

IRON & STEEL PRODUCTS, INC.
40 years' experience
13422-A S. Brainard Ave., Chicago 33, Ill.

WRITE FOR 24 P. CATALOG OF

METERS AND INSTRUMENTS

VOLTMETERS
AMMETERS
MICRO AMMETERS
OHMMETERS
FREQ. METERS
BRIDGES (Wheatstone)
MEGOHMMETERS
RHEOSTATS
VARIABLE TRANSFORMERS
RELAYS

ELECTRO-TECH Equipment Co.
329 CANAL ST., N. Y. 13, N. Y.

POSITIONS WANTED

(Continued from page 4

TRANSFORMER ENGINEER: long design, production radio—lumi and specialty transformers. Exp mass production equipment. PW- ics. 330 W. 42nd St., New York 18

ELECTRONIC ENG. 15 years Europe, 3 years in U. S. manufa cathode ray tubes etc. Exhaust. glass working problems wants po assistant to chief eng. or techn PW-961, Electronics, 330 W. 42 York 18, N. Y.

SELLING OPPORTUNITY W

ELECTRONIC ENGINEER: 14 ye ence as executive research and Maintenance engineer of airborne equipment. Desire sales repre installation and maintenance engi tion. Prefer Central or South Ame Spanish fluently. SA-962, Electron 42nd St., New York 18, N. Y.

Established electronic re sentative sales agency

OPENING FOR A FIELD

For Connecticut, Western Massachusetts ment. Knowledge of and experience electronic parts helpful. A position under contract for the qualified man.

RW-948, (Agency) Electronics
330 West 42nd St., New York 18, N.

TECHNICAL SALES ENGI

Experienced in electronics, or preferably physics. Permanent position and good for man who has technical qualifications to establish firm lasting inter-company Salary open. In replying give full detail experience.

SW-950, Electronics
520 North Michigan Ave., Chicago 11, Ill.

SALES REPRESENTATION WEST COAST

If you are a manufacturer of electrical or electronic equipment for industrial applications, let our staff of experienced engineering consultants represent your products on the west coast. Address

RA-934, Electronics
68 Post St., San Francisco 4, Calif.

RADIO and TELEVISION

Leading Danish manufacturer of radio sets and parts wants connection with American manufacturers in the Radio, F.M., Television and Electrical Music industry, who would be interested in cooperating to exploit present potentialities of Denmark market.

A/S Rasmus Rudholt
Howitzvej 11—Copenhagen F.
Denmark

MERKURIANA

is our cable address. *Wholesale Dealers* and large *Industry* consumers are our clients. We act as Manufacturers' Agent *on your behalf* against a small commission. Open to offers on all Electronic products.

TEKNO-MERKUR
Industrial Agencies
Postbox 617 Stockholm 1, Sweden

FOR SALE

Controlling Stock Interest

in well known transformer manufacture. Excellent opportunity to enter this active business

BO-876, Electronics
330 West 42nd St., New York 18, N. Y.

FOR SALE

PAPER CONDENSER PLANT

Machinery, equipment and materials for manufacturing paper condensers. This is an opportunity for an experienced condenser man to start in business with limited capital.

BO-964, Electronics
520 North Michigan Ave., Chicago 11, Ill.

NAVAL OFFICER

Released from active duty desires to purchase interest in currently operating or proposed AM and/or FM Radio Station. Will also consider Mfg. or Distribution of Electronic Equipment.

BO-952, Electronics
330 West 42nd Street, New York 18, N. Y.

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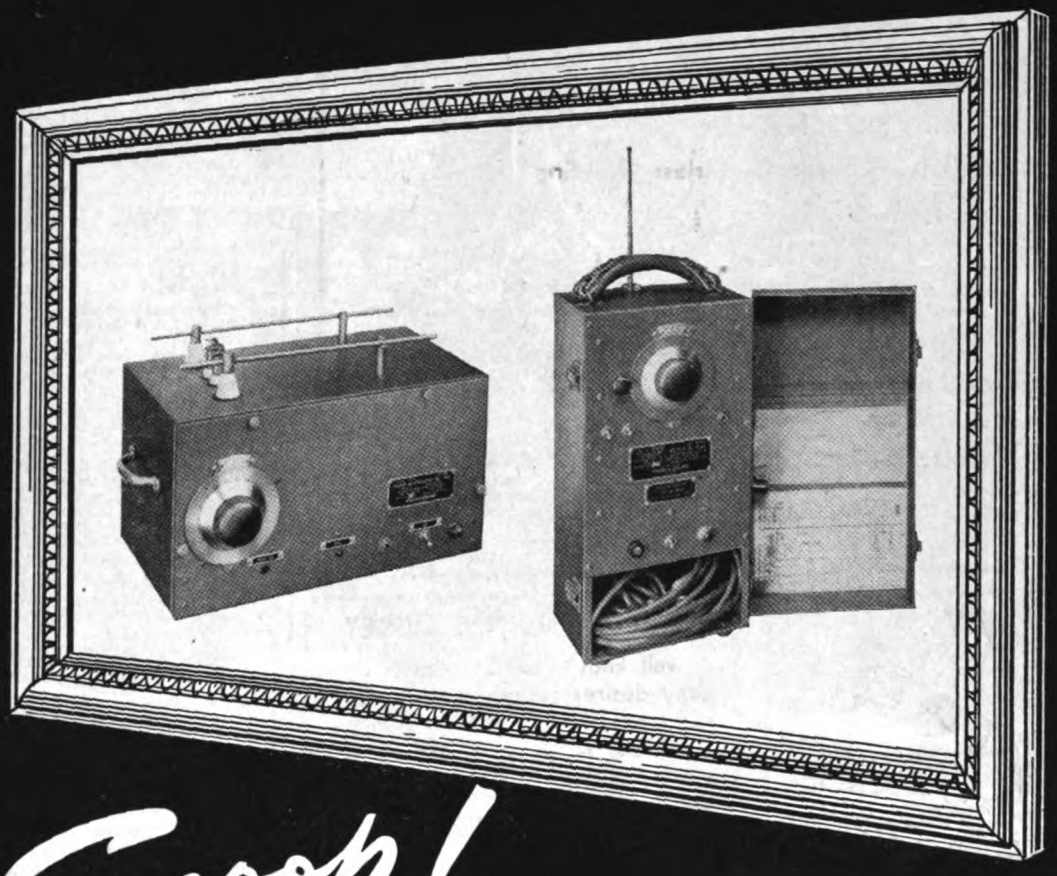

Scoop!

Left: Radio Modulator BC-423. High frequency signal generator operating from 195 to 205 mc., modulated at approximately 5000 cycles. Ruggedly built in steel case. Designed so that it can be re-adapted to many applications. Can be used as high frequency receiver, transceiver or frequency meter. Good for lab demonstrations requiring low power, ultra high frequency generator. Can be converted to 2½ or 1¼ meter receiver.

Right: Frequency Meter BC-438. Ultra-high frequency signal generator operating from 195 to 205 mc. with crystal calibration. Aluminum chassis in steel case. Removable nickel plated 19" telescopic antenna. Use as high frequency receiver or transmitter. Can be converted to cover any frequency range. Takes dry batteries for portable use. Precision tuning control make it ideal for "on the nose" ECO transmitter control unit.

hallicrafters RADIO

THE HALLICRAFTERS CO., AGENT FOR RFC UNDER CONTRACT SIA-3-24
MANUFACTURERS OF RADIO AND ELECTRONIC EQUIPMENT

THESE VALUABLE ITEMS *Available Now* or very soon. Write, wire or phone for further information • head phones • test equipment • component parts • marine transmitters and receivers • code practice equipment • sound detecting equipment • vehicular operation police and command sets • radio beacons and airborne landing equipment.

CLIP THIS COUPON NOW

RFC DEPARTMENT 417 HALLICRAFTERS
5025 West 65th Street • Chicago 38, Illinois

☐ Send further details on merchandise described above

☐ Send listings of other available items

Especially interested in _____

STATE _____

NAME _____

CITY _____

ADDRESS _____ ZONE _____

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Now—MATCH THEIR BEST WITH YOUR MOST IN THE VICTORY LOAN!

Top off your good work on your Payroll Savings Plan with an outstanding showing in the Victory Loan—our last all-out effort!

Help bring our boys back to the homes for which they fought—and give our wounded heroes the best of medical care—by backing the Victory Loan! You know your quota! You also know by past war-loan experience that your personal effort and plant solicitation are required to make your quota.

Sell the New F.D. Roosevelt Memorial $200 Bond through your PAYROLL SAVINGS PLAN!

In rallies, interdepartmental contests, and solicitations, promote the new Franklin Delano Roosevelt Memorial $200 Bond! Better than "cash in hand," Victory Bonds enable the buyers to build for the future—assure a needed nest egg for old age.

Keep on giving YOUR MOST to the Victory Loan! All Bond payroll deductions during November and December will be credited to your quota. Every Victory Bond is a "Thank You" to our battle-weary men overseas—also a definite aid in making their dreams of home come true! Get behind the Victory Loan to promote peacetime prosperity for our returning veterans, your nation, your employees—and your own industry!

The Treasury Department acknowledges with appreciation the publication of this message by

VICTORY LOAN

ELECTRONICS

This is an official U. S. Treasury advertisement prepared under auspices of Treasury Department and War Advertising Council

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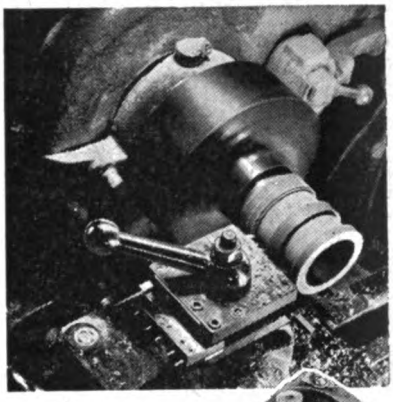

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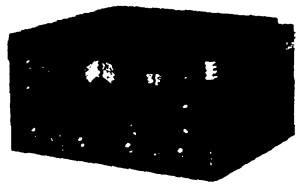

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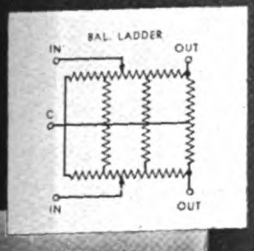

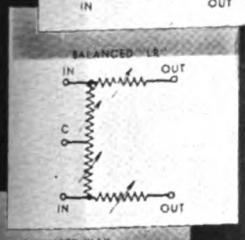

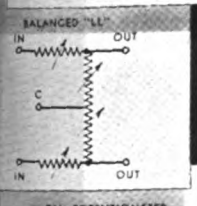

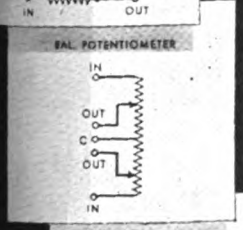

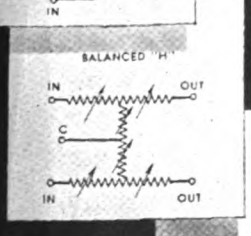

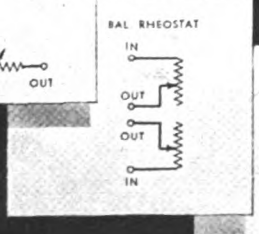

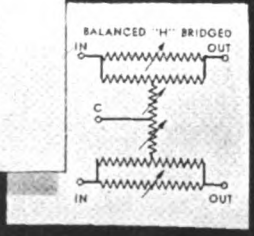

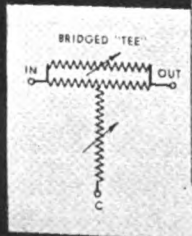

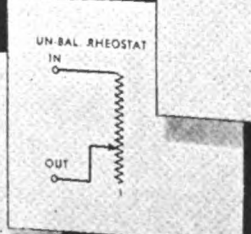

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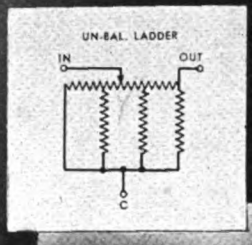

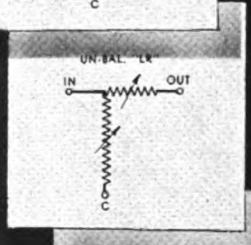

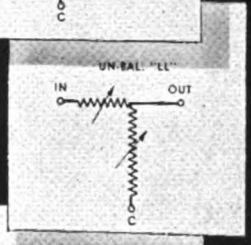

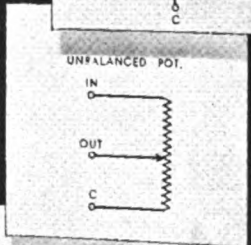

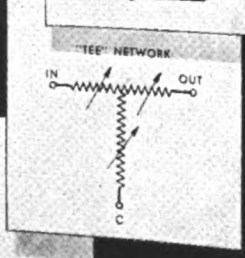

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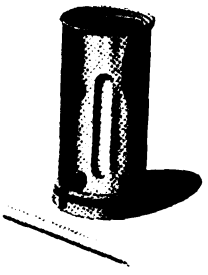

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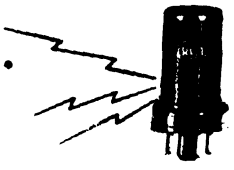

2. CAN BE LOCATED ANYWHERE

Metal tubes are little affected by stray fields.

3. ARE EASILY GROUNDED

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